PROCEEDINGS OF THE 66TH SCIENTIFIC WORKERS' CONFERENCE AND THEME PAPERS ON RICE, PULSES, MAIZE, DRYLAND AGRICULTURE AND ERIOPHYID MITE

TAMIL NADU AGRICULTURAL UNIVERSITY
COIMBATORE 641 003

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Edited

By

Prof.Dr.S.KANNAIYAN
Vice-Chancellor

and

Dr.M.SUBRAMANIAN
Director of Research

TAMIL NADU AGRICULTURAL UNIVERSITY
COIMBATORE - 641 003

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STRATEGIES FOR RICE PRODUCTIVITY

S.KANNAIYAN, M.SUBRAMANIAN AND S.ARUMUGACHAMY

Rice is the important and staple food crop for more than half of the global population. Although rice is cultivated in more than 90 countries spread over 6 continents more than 92% of the rice is produced and consumed in Asian countries. The rice area, production and productivity of important rice growing countries are given in Table. 1

When compared to the other rice growing countries India is having the largest area under rice and second best in production next to China. The rice crop in India, accounts for about 22 per cent of the total cropped area under cereals and about 31 per cent of the total area under food grains. The area under rice in India is around 42 million hectares with an annual production of 86 million tonnes of rice. (110 million paddy).

Tamil Nadu is one of the traditional State for rice cultivation and consumption. Rice production in Tamil Nadu during 1920 was only 15.29 lakh tonnes with the productivity of 805 kg/ha. This has been steadily increased to 19.12 lakh tonnes with a productivity of 1002 kg/ha during 1940's. The most significant achievement of the post independent era is the transformation form chronic deficit to self sufficiency. The percapita net availability of rice (provisional) has increased from about 150 g in 1950 to 225g in 1990, inspite of growing population. In fact the rice area has shrunken from 2.52 million hectares in 1960 to about 2.20 million hectares in 1998-99, but the production has increased from 3.5 million tones to about 8.2 million tonnes in 1998-99 and ranked first in national productivity. Trends in area, production and productivity of Tamil Nadu is given in Table 2 and district wise figures are given in Table 3.

Table 1 Rice Area, Production and Productivity in some rice growing countries

S.No	Country	Area (million ha)	Production (million tonnes)	Productivity (t/ha)
1.	India	42.20	110.94	2.6
2.	China	33.10	187.45	5.7
3.	Indonesia	10.18	44.32	4.4
4.	Japan	12.00	2.05	5.9
5.	Korea (DRR)	5.10	1.21	6.2
6.	Korea (Republic)	7.48	6.20	3.1
7.	Vietnam	19.42	6.20	3.1
8.	Pakistan	4.90	2.10	2.4
9.	Srilanka	2.30	0.86	2.8
10.	Peru	0.84	0.15	5.2
11.	Egypt	3.15	0.43	7.3
12.	Australia	0.13	0.09	8.2
13.	USA	7.06	1.11	6.3

(IRRI, 1994)

Table 2. Rice Area, Production and Productivity in Tamil Nadu

Year	Area (Lakh ha)	Production (lakh tones)	Productivity (kg/ha)
Before Independence			
1920s	18.99	15.29	805
1940	19.08	19.12	1002
After Independence			
1950-55	18.27	20.49	1122
1956-60	23.83	32.95	1382
1961-65	25.93	38.81	1496
1966-70	26.13	40.38	1545
1971-75	26.29	50.80	1932
1976-80	26.63	53.35	2003
1981-85	22.80	46.19	2017
1986-90	20.08	56.28	2803
1991-92	21.18	65.96	3115
1992-93	21.84	68.06	3116
1993-94	23.23	66.82	2927
1994-95	22.28	75.59	3392
1995-96	22.29	75.63	3394
1996-97	22.69	60.61	2671

Table 3. Rice – Area, Production and Productivity in Tamil Nadu – Districtwise (1997-98)

S.No.	District	Area (Lakh ha)	Production (Lakh tones)	Productivity (kg/ha)
1.	Kancheepuram	1.55	5.06	3269
2.	Thiruvallur	1.12	4.35	3886
3.	Cuddalore	1.17	3.58	3071
4.	Villupuram	1.78	5.66	3179
5.	Vellore	0.72	2.37	3308
6.	Tiruvannamalai	1.42	4.06	2852
7.	Salem	0.46	1.88	4044
8.	Namakkal	0.24	0.99	4134
9.	Dharmapuri	0.64	2.04	3166
10.	Coimbatore	0.19	0.58	3083
11.	Erode	0.61	2.69	4417
12.	Tiruchirapalli	0.68	2.24	3300
13.	Karur	0.16	0.49	2954
14.	Perambalur	0.50	1.53	3066
15.	Pudukottai	0.88	2.43	2750
16.	Thanjavur	1.81	4.90	2699
17.	Thiruvarur	1.68	2.86	1697
18.	Nagapattinam	1.57	2.70	1718
19.	Madurai	0.83	3.14	3785
20.	Theni	0.20	0.62	3117
21.	Dindigul	0.28	1.37	4948
22.	Ramanathapuram	1.45	4.80	3322
23.	Virudhunagar	0.36	1.12	3100
24.	Sivagangai	0.91	2.22	2437
25.	Tirunelveli	0.89	3.26	3668
26.	Thoothukudi	0.18	0.79	4392
27.	Kanyakumari	0.31	1.19	3797
28.	The Nilgiris	0.02	0.06	3487
	Total	*22.61*	*68.94*	*3050*

Rice cultivation in Tamil Nadu is not having a smooth take off as it is cultivated in varied climatic, soil and stress conditions under 8 different seasons with rice varieties of 5 different duration groups.

Rice growing seasons in Tamil Nadu

i. Sornavari (Mar-April to June-July)
ii. Kar (April-May to July-August)
iii. Kuruvai (May-June to August)
iv. Early Samba (July-August to Jan-Fab)
v. Samba (Sept-Oct to Jan-Feb)
vi. Late Samba (Oct-Nov to Jan-Feb)
vii. Thaladi/Pishanam (II Crop) Sept-Oct to Feb-March
viii. Navarai (Dec-Jan to April-May).

Duration groups in rice

1. Very early duration : About 100 days
2. Short duration : 100 – 120 days
3. Medium duration : 121 – 140 days
4. Long duration : 141 – 160 days
5. Very long duration : Above 160 days

Constraints

1. Upland

Rainfed and semidry exosystems

a. Rainfed

Seed to seed the crop is depending on monsoon rains

b. Semidry

The dry seeds are sown either pre or post monsoon depending on rainfall received or predicted. Later the crop is irrigated when the tanks are filled up with rains and water received through canals.

2. Soil stress

a. Acid soils

Soils with <5.5 pH with accumulation of higher amount of Iron and Aluminium. The acid soils are not mostly prevalent in Tamil Nadu.

b. Saline and alkaline soils

i) Saline soils

About 20% of the soil is affected by this problem. Those soils possess EC >4, pH < 8.5 and ESP < 15%. Mostly, HCO_3, CO_3, Cl_2, So_4 of Na, followed by Ca and Mg are present in the soil.

ii) Sodic soils

Soils with Ec of <4, pH 8.5, ESP>15% contains Co_3 and HCO_3 of Na, in the soil.

c. Effluents

In textile, tannery, sugar and sago factory areas, the irrigation water is highly polluted because of the effluent discharged from the industries/factories. Either they directly affect rice cultivation or through irrigation water.

The problems of tannery effluents are very common in Vellore, Dindugul and Trichy districts. Textile effluents in Karur and Erode, Sago-effluent in Salem district and sugar factory effluents in almost all districts of Tamil Nadu hampered the rice cultivation considerably. Though varieties are not exclusively available, suitable management practices are to be recommended to alluviate this stress.

At present Tamil Nadu Government has fixed a productivity target of 7 t/ha paddy to increase the rice production in the State. The lands under

rice cultivation in Tamil Nadu are not located in places with favourable conditions throughout. Their location, climatic conditions and environmental factors are entirely different. Therfore, achieving 7 t/ha from all these lands needs proper planning and systematic approach in recommending varieties and package of practices.

Therefore, it is suggested that more attention is to be devoted towards (1) the potential areas with canal fed irrigation, (2) areas with bore well, open well and tankfed irrigation and (3) attention also needs to get high productivity from stress areas with appropriate technology recommendations for rice cultivation.

I. Varieties for irrigated ecosystem

Currently rice research is being taken up at 10 different locations viz., TRRI, Aduthurai, TNAU, Coimbatrore, AC&RI, Madurai, AC & RI, Trichy, AC & RI, Killikulam, Agricultural Research Station, Tirupathisaram, Rice Research Station, Ambasamudram, Rice Research Station, Tirur, Agricultural Research Station, Paramakudi, Regional Research Station , Paiyur and Agricultural Research Station, Ramanathapuram to cater the needs of seven agro climatic regions in Tamil Nadu. So far 149 varieties have been released and 25 varieties have been introduced. Among them 80 varieties are short, 44 and 50 are medium and long duration varieties respectively.

Newly released varieties are highly potential and able to produce >10 t/ha. To quote, following are the examples of high yield potentials of the currently ruling rice varieties.

CR 1009	- 27 t/ha	Gangai Kondan, Thirunelveli district
ASD 16	- 20 t/ha	Alwarthirunagari, Tuticorin district
ADT 36	- 17 t/ha	Madurai district
IR 64	- 18 t/ha	Theni district
MDU 2	- 10 t/ha	Theni district
IR 20	- 10 t/ha	Theni district

Therefore if the varieties are nurtured with required crop management and protected with need based management, they are capable of yielding more than 7 t/ha.

Any package of practice starts with choice of suitable high yielding varieties for the season. Short duration varieties (100 – 120 days) are suitable for Navarai, Sornavarai, Kar and Kuruvai seasons; medium duration varieties are grown in Samba and Thaladi seasons and long duration varieties are suitable for samba season. The following are the rice varieties under cultivation in Tamil Nadu.

i. Short duration varieties/hybrid

ADT 36 (Tiruveni / IR 20): 110 days, 5.5 t/ha, medium slender white rice, resistant to BPH and blast

ADT 37 (BG 280-1-2/PTB 33): 110 days, 6 t/ha, short bold white rice, resistant to many pests and diseases, seed dormancy for 60 days.

ADT 42 (AD 9246/ADT 29): 115 days, 5.9 t/ha long slender white rice, resistant to GLH.

ADT 43 (IR 50/Improved white ponni): 110 days, 5.9 t/ha, medium slender white rice, high tillering and fine rice, resistant to GLH.

ASD 16 (ADT 31/Co 39): 115 days, 5.5 t/ha short bold white rice, medium tillering, more no. grains per panicle, resistant to blast.

ASD 18 (ADT 31/IR 50): 110 days, 7 t/ha, medium slender white rice, resistant to blast.

ASD 20 (IR 18348-38-3/IR 25863-61-3-2//IR 58): 115 days 5.5 t/ha, long slender, white rice, resistant to many pests and diseases.

IR 50 (IR 2153-14-1-6-2/IR 28//IR 36): 110 days, 5.5 t/ha long slender white rice, 5.5 t/ha susceptible to BPH and blast.

TKM 9 (TKM 7/IR 8): 110 days, 6 t/ha, short bold red kernel, resistant to BLB, drought tolerant.

IR 36 (IR 15 61-228/-IR 24-4/*Oryza nivara*/CR 94-13): 115 days, 5.5 t/ha, long slender white rice, resistant to many pests and diseases.

MDU 5 (*O. glaberimma*/Pokkali): 100 days, 5 t/ha, medium slender white rice, resistant to many pests and diseases

CO47 (IR 50 / CO43): 110-115 days, 6 t/ha, medium slender, resistant to blast
ADTRH1 (IR 58025A/-IR 66R): 115 days, 7.9 t/ha long slender, white rice, milde aroma, resistant to stem borer and leaf folder.

ii. Medium duration varieties/hybrid

ADT 38 (IR 1529-680-3-2/IR443252-6-54/IR 7963-30-2): 135 days, 6.5 t/ha, long slender, white rice, resistant to BPH, GLH, leaf folder, susceptible to BLB. There is a problem of reduction of viability after 6 months storage. For this, the seed should be brought down to 12% moisture content.

CO 43 (Dasal/IR 20): 135 days, 5.5 t/ha, Medium slender white rice, tolerant to saline and alkaline soils.

MDU 2 (CO 25/IR 8): 135 days, 5 t/ha, medium slender, white rice, cold tolerant.

MDU 4 (AC 2836/Jaganath): 125 days, 6 t/ha, long slender, white rice, cold tolerant.

CO 46 (T7/IR 20): 130 days, 6 t/ha, long slender, white rice resistant to BPH. Suitable for BPH endemic areas of Coimbatore and Eroide districts only.

IR 20 (IR 262/TKM 6): 130 days 5.5 t/ha medium slender white rice, resistant to stem borer.

ASD 19 (Lalnaganda/IR 30): short slender, 5.8 t/ha, 125 days, white rice, drought tolerant.

CORH 2 (IR 58025A/C2OR): 130 days, 6.1 t/ha long slender white rice, suited to saline alkaline soils also.

Improved White Ponni (Taichung 65/ME 80): 140 days, semi tall, 4 t/ha, fine grain quality rice, lodging type, resistant to RTV

ADT 38, CO 43, CO 45 and CORH2 should be sown during September (early Puratasi) IR 20 and ASD 19 are to be sown during first fortnight of October (late puratasi)

iii. Long duration varieties

CR 1009 (Pankaj/Jaganath): 160 days, 6 t/ha, short bold white rice, resistant to RTV.

ADT 40 (Swarnadhan/R6-3/Sona): 150 days, 5 t/ha, short bold white rice, suited to water logged situation.

ADT 44 (IR 56/OR 142-99): 150 days, 6.2t/ha, short bold white rice, resistant to blast and GLH

CR 1009 is more suitable for August sowing/September planting, where as ADT 40 and ADT 44 are recommended for September sowing.

II. Management practices

1. Nursery

Selection of nursery site, seed, seed rate, seed treatment, fertilizer, weed and water management practices and plant protection measures decide the production of vigorous seedlings.

Nursery site

a) A fertile land with sufficient irrigation and drainage facilities should be selected. 20 cents of land are required to raise seedlings to plant one ha of main field. The nursery area should be away from shade and lamp post, to avoid incidence of pests.

Land preparation and fertilizer management

The land is well prepared / puddled; well decomposed FYM / compost @ 1 ton/20 cents is uniformly spread, again puddled and manures incorporated. Levelled and then raised beds each with 20x2m size should be formed along with 30cm (width) channels alround the beds.

Otherwise 500kgs of green leaf manure are applied, allowed to decompose and then incorporated in to the soil. If the seedlings are to be pulled out on 25th day of sowing 2kg of DAP/cent should be applied as basal or 15.75 Urea + 115kg super phosphate/20 cents should be applied. If the seedlings are not able to be pulled out on 25th day, DAP at 2kg/cent should be applied 10 days before pulling out of seedlings.

If the soil is clay, to avoid root snapping 1kg of DAP should be applied on 10 days before pulling out of seedlings.

If the soil is heavy clay, 1kg of gypsum/cent should be applied 24 hours before pulling out of seedlings from the nursery.

Seeds and seed rate

Quality seed

Certified seeds (pure seed 98%, inert matter 2%, other crop seed (max) 20 seeds, germination (Min) 80% and moisture (Max) 12% or good quality seeds with >80% germination should be utilised for sowing at the appropriate season.

Before sowing the seeds should be soaked in 1.2 specific gravity Nacl solution. (Dissolve 3kg Nacl salt in 18 litres of water). Immersed seed alone selected and thoroughly washed in good water before sowing.

Seed rate (per ha)

Short duration (100-120 days)	60 kg
Medium duration (121-140 days)	40 kg
Long duration (145-165 days)	30 kg

For rice hybrids, seed rate is 20 kg/ha irrespective of the duration.

Seed treatment

i. Dry seed treatment

Mix any one the fungicides like Thiram, Captan, Carboxin or Carbendazim.at 2 g/kg of seeds.

Treat the seeds atleast 24 hours prior to soaking. The treated seeds can be stored for 30 days without loss of viability.

ii. Wet seed treatment

Soak the seeds for 24 hours in Carbendazim or Pyroquilon or Tricyclozole solution (2 g/lit of water for 1kg of seed)

This wet seed treatment gives protection to the seedlings upto 40 days from seedling diseases such as blast and this is better than dry seed treatment.

iii. Azopirillum treatment

24 hours after treatment of seeds with fungicides, the azospirillum and phosphobacteria can be treated each at 3 pockets for the entire seed required for a hectare. Treated seeds are then shade dried. Then the seeds are soaked for 24 hours and incubated for 24 hours, or more till they develop very good sprouting.

Sowing

The sprouted seeds are to be sown on the raised nursery beds as suggested below :

Short duration	3 kg/cent
Medium duration	2 kg/cent
Long duration	1.5 kg/cent
Hybrid	1 kg/cent

Sowing is done in such a way that about 2000-2500 seedlings/m^2 are available in order to generate vigorous seedlings which are short, stout, five leaved with well developed fibrous root system.

Weed management

To manage the weeds in the nursery beds, 10ml of Butachlor / *Thiobencarb or 5ml of Anilophos/cent* should be applied after mixing with sand. At the time of application of herbicide a thin film of water should be retained in the nursery. The water should not be allowed to drain or let it outside for 2-3 days.

Water management

After sowing, the water should be drained next day and should not be irrigated for 18-24 hours subsequently. However, the nursery should be kept wet with sufficient moisture. Otherwise cracks will develop and roots grow long and there *will be problem of root snapping at the* time of pulling out of the seedlings. Fifth day onwards water level should be raised from 1.5cm to 2.5 cm according to the seedling growth.

Pest management

Forty litres of pesticides spray is necessary for covering the 20 cent nursery area.

i. Armyworm:

Drain water from the nursery and spray Chlorpyriphos 20 EC 80ml or Endosulfan 35 EC 80ml during late evening.

ii. Thrips :

Sampling : Pass a wet table tennis bat (painted with white paint) over the foliage in 12 places in the nursery. If thrips population exceeds 60 numbers in 12 passes or if rolling of ½ area of first and 2nd leaves in 10% of seedlings is noticed, apply one of the following insecticides.

Phosphamidon 85 WSC 25ml (or) Monocrotophos 36 WSC 40ml (or) Endosulfan 35 EC 80ml.

iii. Green leaf hopper

Sampling : Take 25 net sweepings in the nursery area. If the population exceeds 60 for 25 sweepings or 20/m^2 by actual counting, spray any one of the following insecticides.

Fenitrothion 50 EC	80ml
Fenthion 100 EC	40ml
Phosalone 35 EC	120ml
Monocrotophos 36 WSC	40ml
Phosphamidon 85 WSC	25ml
Quinalphos 25 EC	80ml
Endosulfan 35 EC	80ml

Maintain 2.5cm of water in the nursery and broadcast Carbofuran 3 G 3.5kg / Phorate 10 G 1.0 kg / Quinalphos 5 G 2.0 kg

iv. Caseworm

Mix 250ml of kerosene to the standing water, dislodge the cases by passing a rope and drain water, collect the cases and destroy. Spary Monocrotophos 36 WSC 40 ml or Quinalphos 25 EC 80 ml.

v. White tip nematode

Presoaking overnight and sun drying for 12 hours at 6 hrs/day for two days, two or three days prior to sowing to denematize the seeds.

vi. Rice –root nematode

Application of carbofuran 3G at 3.4 kg/20 cent nursery

Disease management

i. Blast/Brown spot

If dry seed treatment alone is done, spray the nursery with any one of the following fungicides on observing the initial infection of blast or brown spot in the nursery along with insecticides : Carbendazim 40 g Copper oxychloride 100g ; Mancozeb 80 g ; Edifenphos 40 ml for blast and anyone of the above fungicides except carbendazim for Brown spot.

Spary the nursery with any one of the following fungicides on observing initial symptom of diseases such as blast or brown spot in the nursery along with insecticides, if necessary: Edifenphos 50 EC 25 ml, Carbendazim 50 W 25g for 8 centrs nursery. If the wet seed treatment has been given, blast will not occur for 40 days. Therefore the blast protection measure is not necessary.

ii. Tungro disease

Apply carbofuran 3G @ of 3.5 kg ten days after sowing or spary two rounds (10 and 20 days after sowing) with any one of the following insecticides : Monocrotophos 36 WSC 40 ml. Phosphamidon 85 WSC 40ml, Fenthion 100 EC 40 ml for 20 cents nursery.

2. Main field preparation

The land should be thoroughly prepared and bring it to the tilth condition for planting rice seedlings. Apply 12.5 tonnes of FYM or compost or 6.5 tonnes of green manure/ha. The fields are irrigated and allowed to stagnate for about a week time to allow the green manure to decompose, then the land is well puddled and fertilizers applied as basal.

1. The field should be either applied with blanket recommendation or according to the soil test results. The following are the blanket recommendations of fertilizers.

	N		P		K
			(kg/ha)		
Short duration	125	:	50	:	50
Medium & long duration	150	:	60	:	60
Hybrids	200	:	50	:	50

Basal

	N		P		K
			(kg/ha)		
Short	50	:	50	:	25
Medium	60	:	60	:	30
Long	30	:	60	:	30
Hybrids	50	:	50	:	12.5

When the basal dose of NPK fertilizers applied, the nitrogen should be applied by mixing with gypsum and neem cake in the ratio of 5:4:1 (Urea : Gypsum : Neem cake). In the main field if the green manure is applied, basal N can be skipped. This amount of N as plain urea can be combined either at tillering or at panicle initiation stage for better N recovery.

Level the field, apply 25 kg of zinc sulphate and 10 pockets each of azospirillum and phosphobacterium well mixed with FYM and broadcast uniformly prior to planting.

Planting

The seedlings are to be pulled out at the proper time and then planted. The land should be properly levelled before planting. The following are the appropriate age of seedling suited for planting of different duration rice varieties.

	(days)
Short duration	25
Medium duration	25-30
Long duration	30-35

After pulling out of the seedling the root portion of the seedlings should be dipped in the mixture solution of Azospirillum and ***Pseudomonas fluorescens*** (PF.1) (5 pockets of Azospirillum + 1.5kg of ***P. fluorescens*** are dissolved in sufficient quantity of water to dip seedling to cover one hectare area) for 30 minutes before planting. Then the seedlings are to be planted as given below:

At the time of planting only a thin film of water is retained in the main field in order to regulate the planting at shallow depth. While planting the following spacings should be adopted for different duration rice varieties.

Short duration	12.5x10cm (80 hills/sq.m)
Medium duration	20x10cm (50 hills/sq.m)
Long duration	20x15cm (33 hills/sq.m)
Hybrid	20x10cm (50 hills/sq.m)

Weed management

Apply any one of the herbicides at 3 DAT: Butachlor/Thiobencarb at 2.5 lit/ha anilophos at 1.25 lit/ha. Before applying the weedicides it should be thoroughly mixed with sand and uniformly spread all over the field, while broadcasting the herbicide, a thin film of water is to be retained in the main field and water should not be allowed to drain or let in for 2-3 days.

Top dressing

i. Biofertilisers

Blue green algae is applied at 10 kg/ha on 10th day of planting especially for Kuruvai/Kar rice. Apply azolla one t/ha at 10 DAT for samba and Thaladi rices and allowed to multiply for 3 weeks, then the water in the field is drained and azolla mat is incorporated in the main field. In herbicide applied fields, azolla should be inoculated 10 days after herbicide application.

iii. Chemical fertilizers

Short (kg/ha)	N	K	Medium (kg/ha)	N	K	Long (kg/ha)	N	K	Hybrid (kg/ha)	N	K
15 DAT	25	-	20-25 DAT	30	25	25 DAT	30	-	Tillering	50	12.5
30 DAT	25	25	40-50 DAT	30	30	50 DAT	30	-	Pan.In	50	12.5
45 DAT	25	-	60-75 DAT	30	-	75 DAT	30	30	Heading	50	12.5
						100 DAT	30	-			

For hybrid rice 200kg of N should be applied along with 50kg of P_2O_5 and 50kg of K_2O. ¼ of the nitrogen, 100% of P_2O_5 and ¼ of K_2O should be applied as

basal and the remaining 75% of the 'N' and K_2O should be applied at 25% in combination at tillering, panicle initiation and flowering stages (Heading) as split application.

Water management

As other management practices, water management is also playing a major role in deciding the yielding ability of any rice variety. In the main field, at the time of planting a thin film of water should be retained and subsequently life irrigation should be given on 3rd day to 2.5cm depth. The water level should be gradually raised to a depth of 5cm and it should be retained till the paddy crop attains maturity. Stop irrigation 10 days before harvest. The water level should not be reduced or the fields should not be allowed to dry particularly at critical stages of growth viz., the active tillering, panicle initiation, and heading. Irrigation in paddy field mainly depends on the type of soil. Sandy soil needs frequent irrigation, while clay soils are irrigated with little more interval. Periodically regularise the water management in rice field. Five cm water depth should be retained as described above and the subsequent irrigation should be done when the water level reduced to 1cm.

The water is completely let out at the time of top dressing of fertilizer and subsequently it is irrigated 24-36 hours after fertilizer application. The main field can be drained for 1-2 days after maximum tillering stage. This is called mid season drainage. This will promote proper aeration near rhizosphere and also facilitate escape of toxic gases.

Stress Condition

Upland

Rainfed/semidry rice

Rice although an aquatic plant, is also being cultivated both under rainfed and semi dry conditions. About 5% of the total rice area in Tamil Nadu comes under rainfed cultivation distributed in Ramanathapuram, Pudukkottai, Kanyakumari, Tuticorin, Tiruvallur, Kancheepuram, Virudhunagar, Sivaganga, Cuddalore, Villupuram, Trichy, Perambalur and Madurai districts. The success of the rice under this stress conditions is mainly depending upon the amount and period of rainfall received.

In general the uncertainity of rainfall inhibited the farmers to take up the rice cultivation with fulfledged package of practices. Besides, most of the varieties cultivated in this areas are local ecotypes. They are very tall possess moderate yield and high resistance to drought. To overcome this constraints new varieties have been developed and popularised among the farmers.

Varieties like TKM 9, PMK 1, PMK 2, ASD 17, TKM 10 and TKM 11 are suitable exclusively for rainfed condition.

Short duration

TKM 9 (TKM 7 x **IR 8**): 100 days, 3 t/ha, short bold red rice.

TKM 11 (C22/BJ1): 115-120 days, 3 t/ha, long slender white rice

PMK 1 (CO 25/ADT 31): 115 days, 3.1 t/ha, short bold white rice.

PMK 2 (IR 13564-149-3/ASD 4) : 115 days, 3.2 t/ha, short bold white rice

ASD 17 (ADT 31 / Ratna / ASD 18 / IR 8): 100 days, 3 t/ha, short bold red rice, resistant to blast

Medium duration

TKM 10: (CO 31 / C 22) 135 days, 3.2 t/ha, medium slender white rice

Semidry condition

The varieties suitable are TKM 9, PKM 1, PKM 2, ASD 17, TKM 10, TKM 11, MDU 5, ADT 36, ADT 37, ADT 38, IET 1444, CO 43, Improved White Ponni, ADT 39 and IR 20.

The descriptions of all rice varieties except IET 1444 were already given. The details of IET 1444 is furnished below:

IET 1444 (Rasi) (TNI / CO 29): 115 days, 3 t/ha medium slender, white rice, resistant to blast

Management practice

The following are the important management practices to be followed for increasing the rice productivity under rainfed and semi-dry conditions.

1. Summer ploughing
2. Application of enriched FYM or pressmud
3. Drought tolerant rice varieties
4. Seed hardening
5. Azospirillum treatment
6. Weed management
7. Micronutrients application and
8. Intercultivation

Land preparation

Rainfed and semidry cultivation are depending upon the rainfall during south-west (July-August) and north east monsoon periods (Oct-Nov). The rainfall pattern in each districts is also vary.

The lands are well ploughed during summer immediately after the receipt of the summer showers during May-June. This will help to improve soil physical conditions and eradication of weeds, management of pests and diseases and ease further cultivation operations.

Twelve and half tones of well composed FYM/ha are to be applied as basal and incorporated in the soil by repeated ploughings, if sufficient quantity of compost is not available 750kg of enriched FYM or pressmud/ha may be applied as basal and incorporated.

Gypsum at 500kg/ha can also be applied during last ploughing.

Seed rate

Hundred kilograms of quality / certified seeds are sufficient to cover 1 ha of land. Choose only goods seeds (soak the seeds in 1.2 specific gravity of sodium chloride salt solution immersed seeds alone are used after thoroughly washed with good water)

Treat the seeds with fungisides like Thiram/Captan/ Carbendazim at 2g/kg of seed and keep it for 24 hours.

Seed hardening

Hubdred kilograms of seeds should be soaked in water for 10 hours and then in 1% potassium chloride solution for another 10 hours (400gms of potassium chloride

dissolved in 40 lit of water). Drain the solution, dry the seeds under shade. The moisture content should be brought down to 14%. The treated seeds are utilised for sowing. They can tolerate the drought and produce vigorous paddy seedlings. Sowing should be taken in such a way that about 150-200 paddy seedlings should be present in one sq.m.area which will produce about 500 panicles at the time of maturity.

Azospirillum treatment

Azospirillum is a well suited biofertilizer for upland rice, it provides drought tolerance for the crops, it is available in the root rhizosphere and absorbs the nitrogen from the atmosphere and makes available to the plant. First the seeds are to be treated with azospirillum for which 600gms (3 pkt azospirillum) are well mixed with cold rice gruel at 3:1 ratio and then 100kgs of seeds are mixed with the azospirillum thoroughly for 30 minutes before sowing. Azospirillum should also be applied to the main field at the rate of *10 pkts after well mixing with FYM.*

Sowing

Sow the seeds with the help of gorru in line with (shallow) 2-3cm depth; it facilitates for intercultural operations. During the second day (sowing) gundaka should be used in crosswise and this operations are repeated for 3rd and 4th day, if it is needed. It helps to eradicate the weeds and to retain the soil moisture.

To control the weed 2.5 lit Thiobencarb is mixed with 50 kgs of sand and broadcast uniformly in the main field, when sufficient moisture is available even before the seedlings are germinated. If it is not possible, due to want of sufficient moisture in the soil, it can be done on 8th day after sowing, when there is sufficient moisture.

After a month of sowing, the excess seedlings are thinned out and gap filled to maintain about 150-200 seedlings/m^2. To keep the seedlings drought tolerant, 0.5% potassium chloride spray at the rate 5g/lit should be taken. It is to be repeated when the drought lasts.

Fertilizer management

Basal application

A blanket recommendation of 40:20:20 kg/ha is advocated for rainfed rice as basal. For semidry 125:50:50 NPK kg/ha is recommended for short duration varieties. For medium and long duration varieties, a fertilizer schedule of 150:60:60 NPK kg/ha can be adopted. Phosphorus at 50 kg/ha for short duration and 60 kg/ha for medium and long duration varieties is applied basally as enriched FYM or pressmud. About 750 kg of well decomposed FYM or pressmud/ha are mixed with recommended quantity of Superphosphate (125 kg/ha) thoroughly, heaped covered with wet clay and retained for about 30 days under anaerobic conditions. Potassium is to be applied basally at 25 kg/ha and 30 kg/ha for short and medium, long duration varieties respectively. N need not be applied as basal , for semidry rice.

Top dressing

Generally tillering and panicle initiation stages are the critical periods for top dressing of fertilizers. Nitrogen can be applied in equal splits at 30, 45 and 60 DAS at 125 kg/ha (short duration varieties) and 150 kg/ha (medium and long duration groups). The balance quantity potassium (25 kg/ha for short and 30 kg/ha for

medium and long duration varieties) needs to be top dressed at the time of panicle initiation. At the time of first top dressing, 25 kg $ZnSO_4$ and 40 kg ferrous sulphate can be applied, if there is Zn and Fe deficiencies. If soil application of Zn and Fe is not done, foliar spray of 0.5% zinc sulphate and 1.0% ferrous sulphate can be recommended at 30, 40 and 50 DAS.

Foliar fertilization

If there is no sufficient soil moisture for top dressing of fertilizer, 2% DAP spray is recommended.

Drought management

In the early stage of crop growth, if there is moisture stress, foliar spray of 1% potash (10 g/lit of water) is advocated. To impart drought tolerance, foliar spray of CCC (cycocel) at 1000 ppm (1g or 1 ml/lit of water) can be done when the leaves start to show the symptoms of slight leaf rolling due to drought. CCC spray will aid in the development of deep roots and moisture in the lower layers of soil can be utilised by the crop.

Saline and alkaline soil

About 4.5 lakh hectares of the rice area in Tamil Nadu which is 19.7% of the total rice is having salinity and alkalinity problems. Mostly the coastal salinity is very severe when compared to inland salinity.

The productivity under this condition is very low as compared to normal soil and therefore when rice is cultivated in saline and alkaline soils, appropriate varieties should be chosen along with management practices.

Varieties

At present two medium duration varieties viz., CO 43 and TRY 1, varieties have been released exclusively for both inland and coastal salinity conditions. In addition ASD 16, a short duration variety and CORH 2, a medium duration hybrid and ASD 19, a medium duration rice variety are mildy tolerant genotypes against salinity and alkalinity.

Descriptions for CO 43, ASD 19, ASD 16 and CORH 2 have already been given.

TRY 1 (Trichy 1) (BR 153-20-10-1-3/IR 578 172-2-2/TRI-2-D19): 135 days, 5.3 t/ha, long bold, tolerant to saline and alkaline conditions.

Management practices

Before taking up the cultivation, the soil should be analysed. Based on the pH and EC the ameliorative measures have to be taken up. If the soil is found to be saline, application of organic amendments in conjunction with improvement in drainage will aid in ameliorating saline soils. For alkali soils, the gypsum requirement has to be worked out and application of 50% gypsum requirement along with organic amendments (25 t ha^{-1}) and drainage will help in ameliorating the alkali soils. In alkali soil, zinc deficiency is found to be widely prevalent and basal application of zinc sulphate at 25 kg/ha will supply the required zinc nutrient. If Zn deficiency symptoms occur during the crop growth period, foliar spray of 0.5% zinc sulphate is to be taken up.

Effluents

As per the findings of the Anbil Dharmalingam Agricultural College and

Research Institute, Trichy the spent wash effluent from the sugar factories at the rate of 5 lakhs lit/ha was found to be optimum to reclaim the salinity and also increase grain yield.

Hence, recommendation of rice technologies for the enhancement of rice productivity/ha as recommended for normal conditions may not be suitable. Therefore specific recommendations for specific stress conditions are to be made available. Therefore, much efforts are to be made to concentrate on favourable conditions where normal irrigation facilities and potential soils are available. The second category are the rice fields which lack some facilities may be concentrated to alleviate the lacuna and advocating suitable recommendations according to the requirement of the specific locality. Finally the soils without stress and strains, in general the following are the important technologies to be followed for enhancement of the rice yield.

3. Crop protection

The rice crop is affected by many pests and diseases all through the year starting from nursery to the main field. Among these pests stemborer, leaf folder, green leaf hopper, brown plant hopper, gall midge, blackbug, and ear head bug are note worthy. They cause severe damage in rice crop. Similarly blast, BLB, RTD, brown spot, sheath rot and grain discolouration are the major diseases which incur heavy loss in rice cultivation.

There are many pesticides and fungicides recommendations for these biological menaces. Approach through integrated pests and disease management will be the best to manage these pests and diseases. The following are effective recommendations in managing the pest and disease.

Pest management (Main field)

i. Remove/destroy stubbles after harvest
ii. Trim field bunds to eliminate alternate host plants
iii. Provide effective drainage, if required
iv. Avoid use of excessive 'N' fertilizers
v. Avoid close planting, especially in BPH and leaf folder prone areas/ seasons
vi. Leave 30cm space at every 2.5m
vii. Use irrigation water judiciously
viii. Keep the fields free from weeds
ix. Use light traps to monitor pest incidence
x. Remove egg masses of stemborer
   In BPH prone areas/seasons, avoid use of synthetic pyrethroids, Methyl parathion and Quinalphos and use recommended chemicals at recommended doses.
xi. Use insecticides based on ETLs.

Pests	**E.T. Level**
Stemborer	2 egg masses/m^2 or **10% dead hearts**
Gallmidge	10% silver shoots
Whorl maggot	25% damaged leave

Control measures

i. Green leaf hopper

60 numbers/25 net sweeping or 5 numbers/hill at vegetative stage or 10 number/hill at flowering or 2 number/hill in tungro endemic area.

Spray any one of the following pesticides: Fenthion 100 EC 500 ml, Endosulfan 35 EC 1000ml, Fenitrothion 50 EC 1000ml, Phosalone 35 EC 1500ml, Quinalphos 25 EC 1000ml, Phosphamidon 85 WSC 300ml (per hectare).

ii. Thrips

ETL as in the nursery. Spray any one of the chemicals: Phosphamidon 85 WSC 300ml, Monocrotophos 36 WSC 500ml, Endosulfan 35 EC 1000ml (per hectare).

iii. Gall midge

Release of ***Platygaster oryzae*** parasitised galls @ 1 per 10 m^2 in the main field, 10 days after transplanting gives effective control.

iv. Brown plant hopper

i) Avoid excess use of nitrogen
ii) Control irrigation by intermittent draining
iii) Drain the water before use of insecticides and direct the spray towards the base of the plants. Apply any one of the following insecticides if BPH is present at the rate of 1 hopper/tiller in the absence of wolf spider and 2 hoppers per tiller when wolf spider at 1/hill. Phosphamidon 85 WSC 500ml; Monocrotophos 36 EC 1250ml; Phosalone 35 EC 1500ml; Carbaryl 10% dust 25 kg/ha; Methyl demeton 25 EC 1000 ml/ha; Asataf 75 SP 625 gm/ha; Chlorpyriphos 1250 ml/ha; Carbofuran 3 G, 17.5 kg/ha; Dichlorvos 76 WSC 350 ml/ha; Neem seed kernel extract 5% (25 kg), neem oil 3% (15 lit); Iluppai oil 6% (30 lit).
iv) Set up light traps or yellow pan traps to monitor the BPH population

v. WBPH

Spray Phosphamidon 500 ml/ha for effective control of WBPH.

vi Leaf folder

When 10% leaves are damaged in the vegetative phase and 5% of flag leaf damage is noticed at flowering, spray any one of the following

(per hectare)

Fenthion 50 EC 1000 ml,
Phosphamidon 85 WSC 300 ml,
Monocrotophos 36 WSC 1000 ml,
Chlorpyriphos 20 EC 1250 ml,
Phosalone 35 EC 1500 ml,
Carbaryl 50 WP 1.0 kg,
Quinalphos 25 EC 1500 ml,
Fenthion 100 EC 500 ml,
Dichlorvos 76 WSC 250ml,
Neem seed kernel extract5%(25 kg)

vii. Stem borer

If 2% white ears at initial flowering are noticed apply any one of the insecticides suggested for stem borer (dead heart) control in the vegetative stage.

Release of *Trichogramma japonicum* on 30 and 37 DAT (twice) and *T. chilonis* on 37, 44 and 51 DAT(thrice) followed by three sprays of Monocrotophos 1000ml/ha, on 58, 65 and

72 DAT also reduce the damage. The sprayings are based on ETL.

Release of *Trichogrammu japonicum* against stem borer is effective at 5 cc/ha/release at weekly intervals.

Release of *T. chilonis* against leaf folder is effective at 5cc/ha/release at weekly intervals.

viii. Mealy bug

Spray any one of the following in the initial stage of infestation. Phosphamidon 85 WSC 300 ml; Fenitrothion 50 EC 1000 ml; Phosalone 35 EC 1500 ml; Dimethoate 30 EC 500 ml.

ix. Black bug

Spray Monocrotophos @ 1000 ml/ha or acephate @ 625 g/ha or NSKE 5% for effective control of black bug.

x. Earhead bug

When present at the rate of 5 bugs/100 earheads at flowering and 16 bugs/100 eraheads at milky to grain maturity, dust any one of the following at 25 kg/ha twice, viz., the first during flowering and second a week later Quinalphos 1.5 D, Carbaryl 10% D, Malathion 5% D (OR) Fenitrothion 2% D

Spray any one of the following insecticides twice as above:

Monocrotophos 36 WSC 500ml/ha, Fenthion 100 EC 500 ml/ha, Fenitrothion 50 EC 1000 ml/ha, Malathion 50 EC 500 ml/ha.

Botanical powder formulations viz., NSK, Notchi leaf powder extract, Ipomoea leaf powder and Prosopis leaf powder are effective in reducing the earhead bug population.

xi. Termite

Apply chopped paddy straw treated with Quinalphos 1.5 D @ 25 kg/ha to reduce the harvester termite *(Anacanthoterimus viarum)* damage.

xii. Rice-root nematode

Apply Carbofuran 3G 16.25 kg/ha in 2cm standing water

xiii. White tip nematode

Spray any one of the following

Monocrotophos 36 WSC 500ml, Chlorpyriphos 20 EC 1250ml, Fenthion 100 EC 500 ml, Phosphamidon 85 WSC 300 ml/ha.

xiv. Rat

Use poison bait with 1 part of Zinc Phosphide and 49 parts of popped corn/rice/dry fish or Warfarin 1 part with 19 parts of popped corn/rice/dry fish or Bromodiolone 0.25 w/w (1:49) at 0.005%. Use bait at one part of Bromodiolone + 49 parts of bait and keep inside the field.

Setting up of owl perches effectively reduces the rat damage.

Disease Management

i. Blast

Chemical : Spray any one of the following fungicides on observing initial infection of the disease: Edifenphos 500 ml/ha; Carbendazim 250 g/ha, IBP 500 ml/ha, Tricyclozole WP 500 g/ha.

Spray ***Pseudomonas fluorescens*** (pf-1) formulations (500 g) dissolved in *500 litres of water* and used for one hectare.

Cultural :

a) Remove collateral weed hosts from bunds and channels.

b) Use only disease free seedlings

c) *Avoid excess nitrogen*

d) Apply N in three split doses (50% basal, 25% in tillering phase and 25% N in panicle initiation stage)

ii. Brown spot

Spray Edifenphos 500 ml or Mancozeb 1000 g/ha when grade reaches 3. If necessary, repeat 15 days later.

iii. Sheath rot

Spray Carbendazim 250 g or Edifenphos 500 ml or Mancozeb 1 kg per ha or NSKE 5% or Neem oil 3% or Ipomoea leaf powder extract (25 kg/ha) or Prosopis leaf powder extract (25 kg/ha). First spray at boot leaf stage and second 15 days later. Application of Gypsum @ 500 kg/ha, basally is being adopted. If it is given as two equal splits, once basally and another at active tillering can also effectively reduce the sheath rot of rice.

iv. Bacterial leaf blight

Spray *Streptomycin sulphate* + Tetracycline combination 300 g + Copper oxychloride 1250 g/ha or Neem oil 3% or NSKE 5% or cowdung extract 20%. Spray when grade reaches 3. If necessary repeat 15 days later.

v. Sheath blight

Spray Carbendazim 250 g or IBP 500 ml/ha or Edifenphos 500 ml/ha as foliar spray. Neem cake at 150 kg/ha followed by foliar spray with Neem oil at 3% starting from disease appearance reduces sheath blight intensity. ***Pseudomonas fluorescens*** (pf-1) formulation as seed treatment (10 g/kg); root dipping (1.5 kg/ha) soil application 30 DAT (2.5 kg/ha) and foliar spray (1 kg/ha) *at boot leaf and 10 days later effectively* control sheath blight.

vi. Grain discolouration

Spray Mancozeb at 1000 g/ha or IBP 500 ml at boot leaf stage.

vii. Tungro

To identify the plants infected by tungro virus, collect leaf samples at 6 a.m. The top 10 cm portion of the leaf is immersed in a solution containing 2 g of iodine and 6 g of potassium iodide in 100 ml of water for 15 minutes or 10 ml of tincture of iodide + 140 ml of water for one hour. They are then washed in water and examined. Tungro infected leaves develop dark blue streaks.

RTV management

a) To control the green leaf hopper vector in the main field, two rounds of any one of the following insecticides; Monocrotophos 36 WSC (1000 ml/ha), Phosphamidon 85 WSC (500 ml/ha), Fenthion 100 EC (500 ml/ha) may be sprayed 15 and 30 days after transplanting. The vegetation on the bunds should also be sprayed with the insecticides.

b) Light traps are to be set up to attract and control the leaf hopper vectors as well as to monitor the population and those alighting near the light trap should be killed in the early morning by spraying/dusting the insecticides. This should be practiced every day.

In nutshell the following important practices are to be followed for achieving 7 tonnes/ha.

1. The certified seeds with required quantity alone should be used.
2. Vigorous seedlings should be produced by application DAP in the nursery
3. Application of 12.5 tonnes of FYM or 6.25 tonnes of green manure is a must
4. Fertilizer management according to the soil test results will be more appropriate
5. Application of 500 kgs of gypsum/ha is to be followed
6. Use biofertilizers particularly Azospirillum for seed treatment, seedling treatment and main field applications should be followed optimum age of seedling ie. 25 days for short, 30 days for medium and 35 days for long duration varieties is appropriate for planting.
7. Shallow planting with 80 hills/sq.m. for short , 50 and 33 hills/sq.m. for medium and long duration varieties respectively is good for getting higher yield.
8. Application of zinc sulphate mixed with FYM and application of BGA for Kuruvai crop and azolla for Thaladi and Samba crops are essential.
9. Application of urea mixed with gypsum and neem cake (5:4:1) and split application should be followed strictly
10. Foliar spray of 2% DAP, 1% potash with 1% urea at the time of panicle initiation and heading stages will boost the yield.
11. Proper levelling is a must especially for salt affected soils and increase the depth of irrigation to 5 cm as the stage of the rice crop progresses and subsequent irrigation when the water depth reduces to 1 cm.
12. To avoid field losses, harvest the crop at physiological maturity and subsequently do post harvest technology to save the grain.

Socio-Economic factors

Besides, the adoption of technology, the following socio-economic and institutional factors need consideration for achieving the targetted yield of 7 tonnes per hectare.

Sizeable portions of land are owned by temples, part time land lords and big land lords and they are cultivated by tenants through concealed tenancy system. Hence, the investment on agriculture is not adequate. So, suitable Government polices are necessary to make the cultivator for taking proper decision on investment in agriculture. For that, necessary policy changes need to be effected in the existing land reform measures.

There exist competing demands on agricultural labour due to overlapping of farm operations during kuruvai, samba and thaladi. The harvesting operations of the kuruvai and transplanting operations of samba and thaladi coincide and aggravate the peak season labour demand. A policy on selective mechanisation, with an objective of increased labour use efficiency with minimum displacement of labour should be framed to obviate the peak season labour shortage.

The inputs such as credit, fertilizers, seeds, pesticides should be adequately made available both in quality and quantity in time before the commencement of agricultural seasons.

Suitable training programme may be organised for farmers and agricultural labourers for adoption of all the existing technologies.

Hybrid rice

It is absolutely essential that the rice productivity and production/have to be increased to meet the future demand. Without continuing growth in productivity it will be difficult for most rice dependent countries like India to meet the increasing demands of their people for afordable food. The quantity of rice consumed by some rice growing countries and their projected demand are given in Table 4.

Table 4. Rice consumption and demand

Country	Consumption of rice (kg/yr/ha)		Rice demand (million tonnes)		
	1990	2000	1990	2000	2025
India	66	70	86.10	108.33	145.12
China	94	106	164.57	214.54	264.66
Indonesia	138	152	38.64	48.85	64.21
Japan	62	51	11.73	10.12	10.02
Korea (DRR)	125	149	44.23	58.22	74.96
Korea (Republic)	92	77	62.28	55.28	63.38
Vietnam	146	155	15.72	19.55	27.59
Pakistan	19	24	3.32	5.44	8.85
Sri Llanka	94	111	2.45	3.22	4.05
Peru	36	36	1.21	1.47	2.04
Egypt	28	30	2.33	2.88	3.95
Australia	5	4	0.13	0.12	0.14
USA	6	5	2.31	2.10	2.42
World	55	59	447.19	559.85	757.51

The population growth in India is estimated as 1.9% per annum which needs an annual food production of 220 million *tonnes by 200-02 and 240 million tonnes* by 2000-07. The growth rate in rice production which reached 4.4% in the eighties has come down to 2.3% in the nineties. We should strive hard to achieve a minimum annual growth rate of 2.5% in rice production. A close look at the

situation reveals that the performance of high yielding fertilizer responsive dwarf varieties was excellent between sixties and eighties but their yield potential has reached a plateau posing a problem on future enhancement of rice production by a *quantum jump*. Among the various strategies proposed to break the yield plateau in rice productivity, exploitation of heterosis through the development of "Hybrid rice" which has been proved successful.

With an advent of cytoplasmic male sterile lines, China which started research on hybrid rice programme during 1970, released the first hybrid in the year 1976, which is suitable for sub tropical and temperate zones. More than 100 hybrids have been released in China. The rice production of China has increased tremendously. China has produced 187.45 million tonnes from 33.10 million hectares with an average productivity 5.7 ton/ha as against Indian production of 110.94 million tonnes from 42.2 million hectares with an average productivity of 2.6 t/ha (IRRI 1994). China could produce spectacular yield increase due to hybrid rice cultivation since 1976. (Table 5) In 1991, the area under hybrid rice was 17.6 million hectares against the total area of 33.10 million hectares, and produced 230 million tonnes of rice accounting 55% of the rice area and 66% of rice production. The average yield of hybrid rice was 6.78 ton/ha with an yield advantage of 30 per cent over conventional pure line varieties.

Table 5. Yields of hybrid and conventional rices from 1981 to 1990 in China

Year	Conventional (t/ha)	Hybrid (t/ha)	Hybrid over over conventional (%)
1981	4.1	5.3	29.3
1982	4.4	5.9	31.9
1983	4.8	6.4	33.5
1984	5.0	6.4	28.8
1985	4.8	6.5	34.4
1986	4.9	6.6	35.9
1987	4.8	6.6	38.4
1988	4.5	6.6	45.5
1989	4.5	6.6	45.9
1990	4.6	6.6	41.4

Commercial success of hybrid rice in China has clearly demonstrated the potential for this technology to meet the increased demands in rice. Since then many of the countries like- Vietnam (Sub tropical), Korea (Temperate) India (Tropical), Philippines, Indonesia, Malaysia, Thailand, USA, Egypt, Colombia and Brazil initiated research on hybrid rice production.

In India the ICAR, New Delhi identified this as a top priority area and initiated a time bound goal oriented net

work project on hybrid rice since 1989. This project was further strengthened with the assistance from UNDP/FAO since 1991. Now this project is being operated as national research net work with 12 centres across the country with Directorate of Rice Research as Coordinated Centre.

Two lead centres -
Kapurthala in Punjab(N.India)
Mandya in Karnataka (S.India)
Three strategic research centres -
DRR, Hyderabad
CRRI, Cuttack
ICAR, New Delhi
Seven Associate centres (Region Specific Research)
Paddy Breeding Station, Coimbatore(TN)
Karnal (Haryana)
Patnagar (UP)
Faizadabad, (UP)
Chinchura (WB)
Karjat (Maharashtra)

As a result of concerted and coordinated efforts so far thirteen rice hybrids have been released (Table 6) by both the public and private sector. So like China the hybrid rice has become a field reality in India. All the hybrids, so far released have registered an additional yield ranging from 0.85 - 2.31 t/ha indicating the possibility of cultivating hybrids in large scale in India to enhance the productivity and production of rice.

Table 6 . Rice hybrids released in India

S. No.	Hybrid	Year of release	Parentage	Duration	Yield t/ha Hybrid	Standard Check	Yield advantage over standard check (%)
1	CORH1 (MGR)	1994	IR 62829A/ 10198R	110-115	6.08	5.23 (IR 50)	16.2
2	APRH 1	1994	IR 58025A/ VAJRAM R	130-135	7.14	5.27 (Chaitanya)	35.4
3	APRH2	1994	IR 62829A/ MTU 992R	120-125	7.52	5.20 (Chaitanya)	44.6
4	KRH 1	1994	IR 58025A/ IR 9671 R	120-130	6.02	4.58 (Mangala)	31.4
5	CNRH 3	1995	IR 62829A/ AJAYA R	125-130	7.49	5.45 (Khitish)	37.4
6	DRRH 1	1996	IR 58025A/ IR 40750	125-130	7.30	5.50 (Tellahamsa)	32.7
7	KRH 2	1996	IR 58025A/ KMR 3R	130-135	7.40	6.10 (Jaya)	21.3
8	ADTRH1	1998	IR 58025A/ IR 66 R	110-115	6.43	5.51 (CORH 1)	16.7
9	CORH 2	1998	IR 58025A/ C20 R	120-125	6.07	5.04 (ADT 39)	20.4
10	Pant Sankar Dhan	1997	IR 58025A/UP R192	115-120	6.80	6.20 (Pant Dhan 4	9.7
11	PHB 71	1997	-	130-135	7.86	-	-
12	Sahayadri	1998	IR 55025A / BR827-35-3-1-1-1R	125-130	6.64	4.84 (Jaya)	37.2
13	Narendra Sankar Dhan 2	1998	IR 58025A/ND R3026-4 IR	125-130	6.15	4.94 (Sarjoo 52)	24.5

Out of these 13 hybrids, Tamil Nadu has released 3 hybrids viz., CORH1 (MGR), CORH2 and ADTRH1. Two hybrids viz., CORH 1 and CORH 2 have been released from Paddy Breeding Station, Coimbatore and ADTRH 1 was released from Tamil Nadu Rice Research Institute, Aduthurai. While the CORH 1 (MGR) and ADTRH 1 are early duration hybrids, CORH2 was a medium duration hybrid matures in 125 days. Among the two early hybrids, ADTRH1 was found to be the best and doing very well in all the places it was cultivated.

ADTRH1 was developed by utilising the male sterile line viz., IR 580285A and R line "IR 66R". It is a semi dwarf hybrid with 105cm tall needs 115 days to mature. It tillers profusely and possesses lengthy panicles (27.5cm). Each panicle contains an average of 142 paddy grains and its 1000 grains weigh 23.8 grams. It recorded an average yield of 6.4 tonnes/ha with an increased yield of 16.8 and 15.2% over CORH1 and ASD 18 respectively. The grain is long slender with white rice. The amylose and protein contents were 25.2 and 6.5% respectively. The rice emits a mild aroma on cooking which is highly desirable for biriyani and kushka rice preparations. The milling outurn is 16.8%. It is moderately resistant to stemborer and leaf folder under field conditions and suitable for cultivation in Kar, Kuruvai and Sornavari seasons of Tamil Nadu.

The informations so far gathered from on farm trials conducted at farmers' fields have given encouraging results about the performance of ADTRH 1. This rice hybrid is doing very well wherever it is grown and gives higher yield than short duration varieties viz., ADT 36, ADT 42 and ASD 18. The yield increase being 31 to 58%. The performance of ADTRH 1 both in station as well as farmers field is furnished in the Tables 7 & 8.

Table 7. Performance of ADTRH 1 at Tamil Nadu Rice Research Institute, Aduthurai

Season	ADTRH 1	ASD 18	ADT 36	ADT 42
Kuruvai				
1996 I	6977	--	--	--
II	6740	4902	3779	--
Kuruvai				
1997 I	7990	--	--	--
II	6461	5572	4886	--
Kuruvai				
1998 I	6150	--	--	5800

The medium duration hybrid CORH2 is a derivative of cross between *cytoplasmic male sterile line* IR 58025A and C20R the resotrer. It matures in 125 days and can be grown between July and October. The average yield potential of this hybrid is 6.07 t/ha which is 20.2% increased yield over ADT 39. The grain is medium slender with white rice. This is moderately resistant to blast and WBPH. It can also be cultivated in salt stress condition.

While ADTRH 1 fits very well in Kar, Kuruvai and Sornavari seasons, the medium duration CORH2 rice hybrid is suitable for samba and thaladi seasons (August to October).

Tamil Nadu needs to produce more and more rice to feed the ever *growing population in Tamil Nadu.* for which the hybrid rice cultivation is the only alternate technology. Therefore, the farmers should come forward to take up the hybrid rice cultivation and produce more for the future need. To exploit the full potential of hybrid rice the management practices need to be fine tuned. The experiements conducted at both Coimbatore and Aduthurai revealed the following as suitable package of practices to get the ghest yield in hybrid rice.

Table: 8 *Agronomic practices for Tamil Nadu Hybrid rices*

	CORH 1	ADTRH 1	CORH 2
Parentage	IR 62829A/ IR 10198-66- 2R	IR 58025A / 66R	IR 58025A / C2OR
Duration (Days Season)	110-115 Kar, Kuruvai and Sornavari	115 Kar, Kuruvai and Sornavari	125 Samba, Late Samba Navarai
NURSERY Seed Rate	20 kg/ha (1 kg/cent)	20 kg/ha (1 kg / cent)	20 kg/ha) (1 kg / cent)
Area	20 cents	20 cents	20 cents
Seed Treatment	carbendzim 2g/kg of seed	Carbendzim 2 g/kg of seed	Carbendzim 2 g/kg of seed
Manures / Fertilizer	FYM / Compost 1t /20cent (or) Green manure 500 kg DAP 2 kg/cent at last ploughing.	FYM / Compost 1t/20 cent (or) Green manure 500 kg DAP 2 kg cent at last ploughing	FYM / Compost 1t/20 cent (or) Green manure 500 kg DAP 2 kg cent at last ploughing

Biofertilizer	Seed treatment with Azospirillum 600 g/ha (3 pockets) and phosphobacteria 3 Pockets	Seed treatment with Azospirillum 600 g/ha (3 pockets) and phosphobacteria 3 Pockets	Seed treatment with Azospirillum 600 g/ha (3 pockets) and phosphobacteria 3 Pockets
Weed Control	Butachlor / Thiobencarb 10ml/cent (or) Anilophos 5 ml /cent 6-8 DAS applied by mixing with sand	Butachlor / Thiobencarb 10ml/cent (or) Anilophos 5 ml /cent 6-8 DAS applied by mixing with sand	Butachlor / Thiobencarb 10ml/cent (or) Anilophos 5 ml /cent 6-8 DAS applied by mixing with sand
Seedling age (Days)	20-25	25	25-30
MAIN FIELD			
Field preparation	*well puddled and levelled field*	*well puddled and levelled field*	*well puddled and levelled field*
Organic manure	FYM/Compost 12.5 t/ha (or) Green manure 6.25 t/ha	FYM/Compost 12.5 t/ha (or) Green manure 6.25 t/ha	FYM/Compost 12.5 t/ha (or) Green manure 6.25 t/ha
Fertilizer schedule NPK (kg/ha)	150:50:50	150:50:50	150:50:50
ZnSo4 (Kg/ha)	25	25	25
Gypsum (kg/ha)	500	500	500
Biofertilizer	Azospirillum 10 pockets (2 kg/ha) and phosphobacteria 2 kg/ha	Azospirillum 10 pockets (2 kg/ha) and phosphobacteria 2 kg/ha	Azospirillum 10 pockets (2 kg/ha) and phosphobacteria 2 kg/ha
Basal NPK (kg/ha)	50:50:25	50:50:25	50:50:25
PLANTING			
a) No.of seedlings hill	one	one	one
b) Spacing (cm)	20x10	20x10	20x10
c) Population Sqm	50 hills	50 hills	50 hills
Planting depth (cm)	2-3	2-3	2-3

Weed control	Butachlor / Thiobencarb 2.5 lit/ha (or) Anilophos 2.250 lit/ha 3-5 DAT followed by one land hand weeding	Butachlor / Thiobencarb 2.5 lit/ha (or) Anilophos 2.250 lit/ha 3-5 DAT followed by one land hand weeding	Butachlor / Thiobencarb 2.5 .it/ha (or) Anilophos 2.250 lit/ha 3-5 DAT followed by one land hand weeding
Top dressing (N and K kg/ha)	25 (15 DAT)	25 (15 DAT)	30 (20 DAT)
I	-	-	-
II	25 (30 DAT) 25	25 (30 DAT) 25	30 (40 DAT) 30
III	25 (45 DAT)	25 (45 DAT)	30 (60 DAT)
Water Management Irrigation depth	*Irrigation to 5 cm* depth	Irrigation to 5 cm depth	Irrigation to 5 cm depth
Critical stages	Panicle initiation 45-50 DAS	Panicle initiation 45-50 DAS	Panicle initiation 65-70 DAS
	Heading stage 75-80 DAS	Heading stage 75-80 DAS	Heading stage 95-100 DAS
Last Irrigation	10 days before harvest	10 days before harvest	10 days before harvest
Plant Protection Harvest	IPM At physiological maturity when 80% of panicles turn yellow	IPM At physiological maturity when 80% of panicles turn yellow	IPM At physiological maturity when 80% of panicles turn yellow
Yield	5.9 t/ha 18.8% *increased yield over* IR 50	6.4 t/ha	6.1 t/ha

The additional yield obtained through hybrid rice cultivation is the manifestation of heterosis and the management practices. Therefore the hybrid rice development and extending the area under hybrid rice cultivation will be the important strategy to boost the rice production.

However, there is one constraint in the yield rice technology adoption i.e. seed production. *Currently the seeds are* produced by adopting three line

system i.e., A,B and R lines, A line is a male sterile line, and needs to be crossed with B line to maintain its sterility. Second step involves crossing of A line with R line. R line, when crossed with A line, restores the fertility of the hybrids and also *develops heterotic effect.* It is cumbersome process and involves technical skill and should be done repeatedly for the continuous supply hybrid seeds to the farmers. Therefore, seed production programme should be strengthened and intensified. It needs "Training Programmes" to be organised for the seed growers, farmers and other private agencies who are willing to take up hybrid seed production. Rice hybrid seed production programme itself is a commercial venture and fetches high profit i.e., about Rs.10000/ha with in a period of 3 to 4 months. Therefore, great emphasis should be given for the promotion of training programme for *the seed production regularly.* The trained persons can produce more rice hybrid seeds to cover the whole rice area of Tamil Nadu in planned way. The required quantity of seed for Tamil Nadu should be assessed and produced in a phased manner to distribute the hybrid seeds regularly to the farmers to cover the maximum area under hybrid rice.

Economics of hybrid rice seed production (per hectare)

A. Production cost	
I. Direct costs	
1. Cost of parent seeds	
Female 20 kgs. @ Rs.125/-	Rs. 2500
Male 10 kg @ Rs.30/-	Rs. 300
2. Nursery expenses	Rs. 1000
3. Main field expenses	Rs. 16500
4. Harvest and processing	Rs. 5500
Total	**Rs. 25800**
II. Indirect costs	
Rental of land, depreciation, interest etc.,	Rs. 3000
Toatl cost (I+II)	**Rs. 28800**
B. Gross income	
1. Value of 1000 kg of hybrid seed @ Rs. 50/kg	Rs. 50000
2. Value of 1000 kg of male parent @ Rs. 3/kg	Rs. 3000
3. Value of 3000 kg of straw @ Rs. 0.50 kg	Rs. 1500
Total Return	***Rs. 54500***
C. Net profit (B – A)	**Rs. 25700**

Note : By experience the hybrid seed yield can be increased to 1500 to 2000 kg/ha.

The currently followed seed production in hybrid rice through three line breeding is a cumbersome process and involves lot of resources. Besides the expression of full sterility is often influenced by different environmental conditions, when grown for seed production. Since the male and female parents commences flowering in different periods after sowing the synchronization for effective hybridization is found to be highly variable according to the environments. This condition warrants an alternative approach to exploit hybrid vigour. Two line breeding is one such possibility that emerged following the chance recovery of photoperiod sensitive genic male sterile (PGMS) plant known as Nongken 58S in a *japonica* variety. It was found to be sterile under longer photoperiodism (>14 hrs) and fertile under shorter photoperiodism (<13 hrs). Temperature sensitive genic male sterility (TGMS) sources identified by Chinease and Japanese scientists remained completely sterile under high temperature (>30 °C) and fertile under low temperature (<24°C). Two line hybrids have been successfully developed in China and more than 4 lakh hectares have been covered with these hybrids and seed production by utilising PGMS and TGMS lines have yielded more than 2.0 - 2.5 t/ha, which is far better than 400 kg obtained in three line breeding. The research and seed production programme using this system is in progress in Tamil Nadu Agricultural University research centers at Coimbatore, Gudalur, Trichy, Aduthurai and Ambasamudram. Breeding lines suitable for two line system have been identified at Gudalur. Among them TGMS 29 is found to be promising and many potential hybrid combinations have been identified utilizing that. They are under evaluation in yield trials.Seed production can be taken up with two line system which will be very easy. After undergoing short term training the seed production can be taken up by the farmers, private agencies and seed growers in a larger way.

PROCEEDINGS OF THE DELIBERATIONS MADE ON RICE PROUDCTION TECHNOLOGY GROUP MEETING , 19-20, JULY 2000

The chairman Dr.M.Subramanian, Director of Research presented a detailed review of the Rice. He highlighted the growth rate of rice, rice production, demand, area production and productivity of rice for the world, India and Tamil Nadu. He also explained about various constraints in rice production and suggested to have a choice of high yielding rice varieties based on their duration and their special attributes and their suitability to various stress conditions. He also elaborated the various rice management strategies including integrated pest management practices.

While stressing the need of hybrid rice popularization in rice he said the hybrid technology is the alternate technology to break the yield plateau. He explained that the hybrid rice cultivation is playing a prominent role in increasing rice production in China because of hybrid rice, he said the productivity has been increased from 5.7 t/ha (1981) to 6.6 t/ha (1990). He said that hybrid rice research was started in 1989 in India and so far 13 public sector hybrids and 7 private sector hybrids have been released. He said that seed production is the constraint in hybrid spread. He also stressed the need for involving resistant parents in hybridization to get resistant hybrids, standardization of hybrid seed production and Indica x Japanica crosses for future approach to get more yield.

The Co-Chairman in his remarks stated Tamil Nadu is the leading State in rice productivity. He requested all the Joint Directors of Agriculture to give importance for hybrid rice seed production, since the average seed productivity is only 225 kg/ha.

After the introductory remarks of the Chairman and Co-Chairman, the District Joint Directors of Agriculture have presented their observations in rice cultivation.

JDA, Thanjavur

1. Varietal spread is influenced by the consumer preference
2. ADT 42 and IR 64 have got the delayed germination of 7 to 10 days.
3. IR 72 is cultivated in 500 hectares because it possesses drought tolerance, non-loading yielding and free from pest and disease incidence. Hence it need varietal notification.
4. Non-synchronisation of flowering is the main reason for low seed set in hybrid rice.
5. Seedling throwing technique needs more demonstrations.
6. ADT 38 seeds germinate in ear head during rainly period.
7. For popularizing any new rice variety sufficient quantities of seeds should be made available.
8. The shelf life of the seed harvested in Kuruvai season is low of ADT 42 and IR 50 rices.
9. The improved white ponni seeds produced in differents regions varies in seed size. Reasons may be explored.
10. ADT 43 Covered 20% area out of 40,000 hectares in Thanjavur district.

JDA, Ramnad

1. A high yielding rice variety suitable for growing between October to December is not be evolved.
2. 1/3rd of the rice area is under sandy soils, a suitable variety is needed.

JDA, Nagapattanam

1. ADT 43 records less yield when one or two irrigations are deficit, where as TKM 9 and ADT 42 tolerate moistures stress.
2. Adequate breeder seed of TKM 9 may be provided.
3. 36 hours soaking of ADT 38 seeds have good germination it needs confirmation.
4. Since the culture AD 97191 performs better, it may be recommended for release in the place of CR 1009.
5. The performance of KRH 1 rice hybrid is good.
6. The possibility of seed production of ADTRH 1 in Thaladi season may be explored.

JDA, Tiruvallur

1. The IR 58025A line obtained from TNAU, Coimbatore was found to have poor germination and also more off-types. The Seed Production programme also warrants timely supply of seeds, periodical inspections and guidance from Scientists.
2. ADT 43 does well and more than 30% of the area covered by this area.
3. When ASD 19 is sown in late Samba or Navarai, it is affected by blast,
4. Improved White Ponni is prone to lodging and varieties like ADT 38, ADT 39 fetch low market price. The variety BPT 5204 of Andhra origin is more popular because of finest grain type even through the variety is a bank for all diseases. Hence, the need for non-lodging, quality improved, medium duration, pest and disease tolerant variety for their District is must.
5. Trichy 1 (TRY 1) performed well in the District. Necessitates mass demonstration trials to estimate its overall performance. The seed production programme is to be strengthened.
6. Andhra Pradesh varieties like BPT 5204, MTU 1001 and Saket 4 etc. have entered this District from the border areas. These are raised by farmers of this District. TNAU Rice Research Station situated at Tirur may conduct location trial and performance of these varieties assessed.
7. A modern Gorru is needed to suit direct seedling.

JDA, Kancheepuram

1. Medium duration variety with fine rice on par with Improved White Ponni may be evolved. He also needed a blast resistant variety suitable for late Samba Season (October-November).
2. ASD.19 Paddy raised during the months of November-January 2000 were severely affected by Blast and yellowing. Therefore suggestion were sought to overcome this problem.
3. As the performance of TRY 1 is poor in Kancheepuram District, a Saline-Alkaline resistant medium duration paddy variety needs to be evolved.
4. In the present context of labour shortage, power tiller attached Paddy transplanter may be designed.
5. Organic Farming production technology for Rice Crop is needed.

JDA (Extension), Chennai

1. Though the productivity is increased in Tamil Nadu for the past several years, in certain districts the average yield is getting down in district like Ramnad and Nagapattinam for the past few years. Hence management strategies for each district may be concentrated.
2. KRH 1 rice hybrid performing better in Tamil Nadu since 90% of seeds

received through National seed corporation.

3. *The Performance of Entry 2 was good* in several areas duing 1997-98. Hence this may be notified.

Reply by Scientists

Professor and Head, Seed Science and Technology

1. Rate of seed germination is genotype specific. ADT 42, IR 64 and IR 50 may have 7 to 13 days delayed germination. To alleviate this problem, treatment of seeds with 0.5% Potassium Nitrate Solutions is suggested.
2. In ADT 38 the seed dormancy may be partial. Due to this delayed germination is noticed. If the seeds are soaked in water for 36 hours, it will improve the germination by leaching out of inhibitors.

Hybrid Rice Breeder, TRRI, Aduthurai

1. The ideal season for hybrid seed production is May 15th to June 15th For want of isolation distance during first season, the seed production is mostly *taken up in thaladi which is to be* discouraged.
2. At the time of reproductive phase the maximum day temperature should not exceed 32 ^{O} C.
3. ADTRH 1 rice hybrid is having good qualities for consumer preference.

Director, TRRI, Aduthurai

1. The seed production of hybrid rice may be taken up during early kuruvai to get higher seed yield with less moisture in seeds.
2. *Seedling throwing gives equal* yield as that of transplanted crop with labour saving of 25%

3. The seed quality of improved white ponni varies with soil type and *irrigation water*.

Director of Research

1. In Ramnad district the rice is grown in three different situations. PMK 1 and PMK 2 suit for the district, however the reasons for low spread of these varieties should be studied. TKM 11 may be tested in this district.
2. The Associate Professor and Head, RRS, Tirur is requested to observed the varieties introduced from Andra Pradesh.
3. *It will not possible to recognize all the* varieties introduced from other states. But where ever may problem is reported suitable remedial measures may be suggested.

Associate Professor, Seed Sci. and Tech.

1. Among the 21 FLD conducted during 1998-99, the performance of ADTRH 1 and CORH 2 rice hybrid excelled the local checks in 17 locations.
2. Hybrid seeds cannot be stored for a longer period. Hence timely indent *and sowing is essential*.

Associate Professor and Head, RRS, Tirur

1. ASD 20 is not recommended for Tiruvallur and Kancipuram districts. An errata for crop production guide was already issued.
2. ADT 43 is suited variety from A.P. BPT 5204 is susceptible to all pest and diseases.
3. ADT 43 is suited for Sornavari season only. It should not be grown in other seasons.
4. The medium duration cultures developed by involving Improved

White Ponni, IR 50, TKM 11, ADT 39, ADT 38, in various crosses are in different stages of evaluation at Rice Research Station, Tirur which will be tested under ART of Tiruvallur and Kanceepuram Districts in due course.

Dr.P.Vivekandan, Professor and Head, (Agrl.Botany)

ASD 20 should be grown only during Sornavari, Kar and Kuruvai seasons and not in Samba and Thaladi / Pishanam seasons.

Dr.O.S.Kandaswamy, Professor (Agronomy)

He stressed that seedling throwing is a very good technique and success of it depends on through leveling, use of 15-20% excess seedling, use of 15 to 20 day old seedlings, not to use force while throwing and Nitrogen applications in 4 splits.

Dr.Savitiri, Professor (SS & AC)

1. In *Kanyakumari district*, *Iron* toxicity is observed in acids soils which leads to yellowing. To alluviate this problem application of the micronutrient mixture namely 1% DAP, 0.5% Zinc Sulphate, 0.2% Borax, 0.2% Copper Sulphate and 1% Murate of Potash may be sprayed.

TECHNOLOGIES ORIENTED PULSE PRODUCTION

S.KANNAIYAN, C.SURENDRAN, AR.MUTHIAH, T.V.KARIVARADARAAJU AND M.SUBRAMANIAN

In Tamil Nadu, pulses are cultivated in about 8.2 lakh hectares with a production of 3.71 lakh metric tonnes. A wide array of pulse crops is cultivated here, which includes redgram, blackgram, greengram , cowpea, bengalgram and soybean. The average productivity is around 449 kg/ha; which is very low when compared to Indian average (534 kg/ha) and global average productivity of 797 kg/ha.

District wise cropped area, production and productivity of major pulses *viz.*, redgram, blackgram, greengram, horsegram and bengalgram is furnished in Appendix 1.

Details of ruling varieties in redgram, blackgram greengram, cowpea, horsegram, bengalgram and soybean along with varieties of rice fallow pulses is furnished in Appendix 2.

A lot of opportunities are available to increase the productivity in Tamil Nadu now, since many field oriented easy-to-do, cheap and effective technologies have been developed by Tamil Nadu Agricultural University, Coimbatore. They are as follows:

I. Technologies (cropwise)

1. Redgram

Redgram may be cultivated under irrigated condition during February – March as a sole crop in all districts except Kanyakumari and the Nilgiris. Short duration varieties like CO 5, Vamban 1 and APK 1 are suitable to this situation. COPH 2 hybrid redgram can be grown in districts like Salem, Dharmapuri, Coimbatore, Erode, Vellore, Tiruvannamalai and Trichy districts under irrigated conditions. Under rainfed conditions SA 1 redgram is to be replaced with Vamban 2 redgram.

The flower shedding and pod shedding in redgram can be controlled by foliar application of NAA (40 ppm) at flower initiation stage and 15 days thereafter increased the yield to the tune of 23.6% over control.

2. Blackgram

i. Rice fallow

The crop can be cultivated under rice fallow condition in the command areas of cauvery delta, Tambiraparani river basin and Lower Bhavani project area during January – February. Varieties like ADT 3 and ADT 5 are suitable and are to be sown with higher seed rate in case of broadcasting (1 ½ times more seed rate than normal seed rate of 20 kg/ha) for ensuring optimum plant stand. Foliar application of 2% DAP twice at flowering is highly essential to increase the grain yield.

Yield reduction by water stress at vegetative stage could be ameliorated by foliar spray of 0.5 per cent K during flowering. The treatment was found to be very effective in increasing the grain yield.

ii. Summer irrigated

It may be sown during February – March as pure crop in Chengulpattu, Vellore, Cuddalore, Dharmapuri, Tanjore, Trichy districts with varieties like ADT 5,TMV 1 and
CO 5, KM 2 is suitable for Sivagangai and Virudhunagar. Erode and Coimbatore districts
can be cultivated with Co 4, CO 5 and TMV 1 blackgram varieties.

Yield reduction by water stress at vegetative stage could be ameliorated by foliar spray of 0.5 % K in the form of KCl during flowering. The treatment is very effective and increased the grain yield.

3. Greengram

i. Rice fallow

The sowing may be taken up in rice fallow of the command areas of Cauvery delta, Tambiraparani river basin and lower Bhavani project area during January – February with varieties like ADT 2 and ADT 3 using higher seed rate (1 ½ times more than normal seed 2rate) in case of broadcasting 2% DAP as foliar spray for two times increased the grain yield.

The water stress at vegetative and flowering stages could be mitigated with foliar application of 0.05% KCl.

ii. Summer irrigated

Greengram can also be cultivated as a sole crop during February / March in the districts of Chengulpattu, Vellore, Cuddalore and Pudukottai with CO 4, KM 2 and CO 6 varieties. CO 4, CO 6 and Paiyur 1 varieties are suitable for Salem, Dharmapuri, Erode and Coimbatore districts. For Madurai, Ramnad, Virudhunagar and Sivagangai CO 4, KM 2, Paiyur 1 and CO 6 varieties are highly suitable.

The water stress at vegetative and flowering stages could be mitigated with foliar application of 0.05% KCl.

4. Soybean

i. Rice fallow

Soybean can be cultivated in rice fallows during January – February in the command area of Cauvery delta, Tambiraparani and lower Bhavani project area with CO 1 and ADT 1 varieties using seed rate of 80 kg/ha with two times foliar plication of DAP at 2% during owering.

Foliar application of salicylic acid gm/500 litre of water/ha. on 30th and th day of sowing / dibbling increases e flower production, delays the nescence and enhances the pod yield.

ii. Summer irrigated

Soybean can be grown as pure crop during February – March with CO 1, CO 2, MACS 124 and JS 335 varieties in all the districts except Kanyakumari and the Nilgiris.

Foliar application of salicylic acid 50 gm/500 litre of water/ha. on 30 and 45th day of sowing increases the flower production, delays the senescence and enhances the pod yield.

In soybean, peak flowering stage was the most critical stage for moisture stress as evidenced from the lowest grain yield (198.2 kg/ha) followed by stress at pre flowering stage (224.2 kg/ha).

Foliar spraying with Kaolin 3 per cent or liquid paraffin at 1 per cent can be given as stress alleviating measure during periods of water scarcity.

iii. Intercropping

Soybean may be cultivated as an intercrop in sugarcane, tapioca and banana crops during January - February with CO 2 and also in the inter spaces of coconut tress of less than five years age.

Intercropping of CO 1 soybean in ridge side planting gives 800-970 Kg/ha without any adverse effect on cane yield.

5. Cowpea

Cowpea can be cultivated as a sole crop during February - March in the districts of Salem, Coimbatore, Erode, Madurai, Trichy and Tirunelveli with CO 2 (Vegetable), Vamban 2 (Vegetable) CO 4 and CO 6 varieties.

6. Bengalgram

Foliar application of urea 2% twice (at flowering and at 15 days later) gave a grain yield of 712 Kg/ha with a gross income of Rs.3560/ha as against 625 Kg/ha and Rs.3127/ha for water spray.

Bund cropping

Pulse crops such as blackgram, greengram, soybean, cowpea redgram may be raised as bund crop/border crop depending upon the field situation to increase productivity of pulses.

For intercropping sorghum with pulses sow one paired row of sorghum alternated with a single row of pulses. The spacing between the row of sorghum and pulse crop is 30 Cm.

The following techniques should be followed for increasing the productivity.

1. Optimum plant stand should be maintained (33 plant/m2) except redgram (11 plants/m2)

2. Seed hardening as specific for pulses may be followed for drought management, population maintenance and help in water use efficiency

3. Specific rhizobium strains (600 g/ha as seed treatment) may be used for all pulses

4. Phosphobacteria (600 g/ha as a seed treatment) application is recommended for increasing the phosphorus use efficiency

5. Application of Trichoderma (4 gms/kg of seed) as seed treatment has been recommended for the control of diseases

6. Application of Sulphur through gypsum at 40 kg/ha to pulses was found to be advantageous in enhancing the yield in sulphur deficient soils

7. Adoption of integrated weed management practices for irrigated pulses is recommended.

Note

Seed treatment with Trichoderma @ 4g/kg or Pseudomonas fluorescens @ 10 g/kg seed shall help in nematode control.

Application of Carbofuran 3 G @ 1 kg a.i/ha at the time of sowing in areas where the nematode is a serious problem. The chemical cost is very high.

Rice fallow pulses technology

1. Remove all discoloured seeds and use seeds with normal colour (black colour in blackgram and olive green in greengram)

2. Seeds retained by the sieve BSS 7 x 7 (2.36 mm width) for large seeded varieties and 8 x 8 (2.00 mm width) for small seeded varieties are to be used.

3. If hard seed percentage exceeds more than 10% commercial H_2SO_4 may be used for scarification for 2 min, washed and shade dried.

4. Soak greengram seeds in aqueous solution of managenese sulphate 100 ppm and for black gram in 100 ppm zinc sulphate for three hours in 1/3 volume of seeds and quickly air-dry in shade to their original moisture content and used for sowing after treatment with thiram @ 2g/kg of seeds.

5. Supplementary foliar spray of 250 litres of aqueous solution /ha containing the following:

Chemicals	Blackgram	Greengram
Urea	7.5 kg	10 kg or 7.5 kg
DAP	1.95 kg	2.6 kg or 1.95 kg
Muriate of Potash	1.31 kg	1.75 kg or 1.31 kg
Potassium sulphate	1.05 kg	50 g
Succinic acid	40 g	50 g
Teepol	125 ml	125 ml
First spray	25 DAS	25 DAS
Second spray	40 DAS	40 DAS

II.PULSES MANAGEMENT TECHNOLOGIES

* Treat pulses seeds with specific strains of Rhizobium for increasing the yield for better nodulation maintenance of organic matter in the soil is essential (favourable CN ratio is 10:1).

* All pulses can not be inoculated by a single rhizobial strain. Even in that case particular species of Rhizobium may not possess the efficiency for a long time.

This necessitates the introduction of newer strains to maintain the nitrogen efficiency and thereby increasing the productivity. At TNAU newer strains were introduced for crop specific

Rhizobium	Percentage of increase in yield	Host crop
CoG 15	30	Green gram
CoC 10	23	Black gram
CC 1	12-60	Red gram
Co Be 13	25-30	Bengal gram
CoC 10	35	Cowpea

Combined inoculation

Combined inoculation of Rhizobium with phosphobacteria (*Bacillus megaterium* and *Pseudomonas striata*) with red gram, black gram, green gram and bengalgram improved grain yield.

Maximum grain yield was recorded by combination of rhizobial strain with phosphobacteria with full dose of N & P in red gram (986 kg/ha) which was 34.70 per cent higher than the uninoculated control. Dual inoculation with half dose of fertilizer gave an yield of 880 kg/ha which was 20.22 per cent higher than control.

Seed hardening – cum - invigouration of pulses

The process of seed hardening followed by invigouration is given as a pre-sowing seed treatment, helps the pulses seed to germinate early by utilizing the available soil moisture. In the case of drought soon after sowing the hardened-cum-invigourated seeds will withstand drought much better then untreated seeds.

Two seed management practices namely seed hardening and invigouration are combined in one process using cheap and easily available materials. The steps involved are:

The invigouration process accelerates seedling growth and suppresses the weed growth. Better and early germination result in higher population per unit area and contribute for higher yield.

Seed hardening

Pre-conditioning

The seeds are pre-conditioned by placing them in between two moist gunny bags for a period of 1 hr. The gunny bags are first soaked in water, then excess water is removed by squeezing and used for pre-conditioning. The seeds are spread to a depth of 1 to 2 cm on the gunny bag.

Soaking and Drying

The pre-conditioned seeds are then soaked in aqueous botanical leaf extracts of Prosopis and Pungam using 1% solution each mixed in 1:1 ratio. To prepare 1 lit. of botanical extract, weigh 10 g in each of Prosopis and Pungam fresh leaves, macerate into a paste and make up the volume to 1lit. of water.

Soak the pre-conditioned seeds in this prepared solution using 1:0.3 ratio. That is for 1 kg of seeds 200 ml of leaf extract. Gently stir this seeds occasionally to enable uniform absorption. After 1 hr., drain the solution and dry the seeds in the shade.

Invigouration

Following seed hardening the seeds are treated with halogen formulation at 3 g kg-1 of seed. Halogen formulation is prepared by taking 5 parts of pure bleaching powder with 4 parts of finely powered chalk powder and 1 part of arappu leaf powder and mixed in a closed container. This treatment can be given to the seeds at the time of drying (when the surface moisture is removed) and then dried back to safe moisture level.

The seeds treated can be sown immediately or can be stored upto 1 week prior to sowing.

III. Pulses protection technologies

Insect Pests

Red gram

* Protection of the seedlings against insect pests

If sucking pests are noted, spray methyldematon 25EC 500 ml or dimethoate 30EC 500 ml and phosphamidon 85 WSC 250 ml/ha (250 lit spray fluid/ha)

* Protection inflorescence and pods from pod borers

The economic threshold levels for the following insects are:
a. Maruca testulalis 3/plant
b. Exelastes atomossa 5/plant

Whenever Heliocoverpa is predominant, apply NPV at 500 LE/ha in 0.1% Teepol. Apply any one of the following insecticides at 25 kg/ha, endosulfan 4% D; quinalphos 4% D; carbaryl 5% D or spray endosulfan 35 EC 1.25 lit. monocrotophos 36 WSC 625 ml/ha.

Spraying NSKE 5% twice followed by triazophos 0.05% NSKE 5%, Neem oil 2% or phosalone 0.07% are effective in the management of pod borer complex and for higher yield.

Blackgram and Greengram

* Protection of early sucking pests and stemfly

Apply carbofuran 3G (30 kg) or Aldicartob 10G(10kg /ha) in soil at the time of sowing against stemfly and sucking pests. Spray endosulfan 35 EC 50 ml/ha a week after germination and again 10 days after first round, if soil application has not been done. Seed pelleting with dimethoate at 5 ml/kg followed by one round of spraying endosulfan 0.035%.

Method of pelleting : Dissolve 1g in 20 ml of water. Add 5 ml of Dimethoate, pellet seeds and shade dry.

* Protection of young plants

If sucking pests are noted, spray methyl dematon 25 EC 500 ml; or Dimenthoate 30 WSC 500 ml or Phosphamidon 85 EC 250 ml/ha (250 lit. spray fluid/ha).

* Protection of the inflorescence and pods from insect pests

Apply any one of the following insecticides at 25 kg/ha, Endosulfan 4% D, Quinalphons 15% D; Phasalone 4% D and Carbaryl 5% D or spray endosulfan 35 EC 1.0 lit. or Monocrotophos 36 WSC 500 ml (spray fluid 500 lit/ha)

Application of neem seed kernal extract 5% twice, starting from 50% flowering stage followed by one round of endosulfan 0.07%.

Bengalgram

* Protection of flowers and pods

Apply any one of the following at 25 kg/ha phosalone 4% D, quinalphos 1.5% D; carbaryl 5% D; NPV 250 larval equivalent /ha NSKE 5% 25 Kg or spray per ha endosulfan 35 EC 1.0 lit. or monocrotophos 36 WSC 500 ml (500 lit. spray fluid/ha). Spray endosulfan 0.07% in combination with neem oil 0.01% for effective control of Helicoverpa. Three sprays of NPV along with 10% leaf extract of Vitex negundo to control Helicoverba.

IV. Nematodes

The pigeonpea cyst nematode, *Heterodera cajani* is a major problem in greengram, cowpea, blackgram, redgram and gingelly. This nematode is confined to Coimbatore, Erode, Trichy and Pudukkottai districts causing 19 to 45% yield loss in pulse crops.

The technologies developed for the management of cyst nematodes in pulses are as follows :

1. *Avoid continuous cultivation of pulse crops*
2. Crop rotation with cereals such as cholam, cumbu and not with gingelly
3. Cultivation of field tolerant greengram varieties viz., CO 4 (Kovai and Erode districts) and Vamban 1 (Trichy and Pudukkottai districts).

V. Diseases

Root rot of blackgram and greengram

Seed treatment with Trichoderma viride 4g/kg + Pseudomonas fluorescens 10 g/kg seed .

Bengalgram wilt and root rot

Cumbined application of Trichoderma viride 4 g/kg + Pseudomonas fluorescens 10 g/kg seed at S.T.

Blackgram root rot and nematode infection

Basal neem cake application at 150 kg/ha

Powdery mildew of greengram

Spray NSKE (5%) or neem oil (3%) twice at 10 days interval from initial diseases appearance.

Table : 1 Area, production and productivity of Redgram in Tamil Nadu

Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
1.41	1.22	864

Table : 2 Important Districtwise Area, Production and Productivity in Tamil Nadu

Districts	Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
Vellore	0.20	0.27	952
Dharmapuri	0.25	0.28	1012
Salem	0.19	0.18	965
Tiruvannamalai	0.17	0.12	728
Trichy	0.14	0.06	435
Villupuram	0.08	0.07	864
Madurai	0.07	0.08	1101
Pudukottai	0.06	0.03	469
Coimbatore	0.02	0.02	1000
Erode	0.03	0.03	888

Table : 3 Area, production and productivity of Greengram

Total area (lakh ha)	Total production (lakh tons)	Productivity (Kg/ha)
1.63	0.78	480

Table : 4 Districtwise Area, Production and Productivity (Important Districts only)

Districts	Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
Salem	0.17	0.14	847
Kancheepuram	0.14	0.08	562
Coimbatore	0.12	0.08	671
Madurai	0.16	0.05	287
Erode	0.08	0.03	329
Virudhunagar	0.10	0.05	463
Dharmapuri	0.07	0.03	554
Rice fallow Districts			
Nagapattinam	0.21	0.05	231
Thanjavur	0.14	0.03	211
Tuticorin	0.12	0.06	554
Trichy	0.04	0.03	478
Cuddalore	0.02	-	193
Tirunelveli	0.03	0.01	319
Villupuram	0.04	0.02	478

Blackgram

Table : 5 Total Area, production and productivity in Tamil Nadu

Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
3.67	1.43	390

Table : 6 Important Districts Area, Production & Productivity

Districts	Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
Cuddalore	0.46	0.14	297
Villupuram	0.35	0.14	390
Tiruvannamalai	0.22	0.11	508
Salem	0.24	0.17	681
Dharmapuri	0.08	0.04	538
Pudukottai	0.16	0.06	390
Kancheepuram	0.13	0.08	607
Dindigul	0.11	0.06	584
Coimbatore	0.10	0.05	512
Erode	0.07	0.03	390
Rice fallow Districts			
Nagapattinam	0.46	0.13	287
Thanjavur	0.32	0.05	161
Trichy	0.21	0.10	466
Tirunelveli	0.23	0.03	136
Tuticorin	0.23	0.13	550
Cuddalore	0.22	0.10	263

Table : 7 Area, production and productivity of Horsegram in Tamil Nadu

Total area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
1.23	0.53	431

Table : 8 Important Districtwise Area, Production & Productivity of Horsegram in Tamil Nadu

Districts	Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
Dharmapuri	0.66	0.30	455
Salem	0.16	0.08	500
Vellore	0.07	0.03	428
Coimbatore	0.08	0.03	375
Erode	0.05	0.02	400
Tiruvannamalai	0.03	0.01	333
Dindigul	0.04	0.02	500
Pudukottai	0.02	0.01	500

Table : 9 Total Area, production and productivity of Bengalgram in Tamil Nadu

Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
0.10	0.05	527

Table : 10 Important Districts Area, Production & Productivity of Bengalgram in Tamil Nadu

Districts	Area (lakh ha)	Production (lakh tons)	Productivity (Kg/ha)
Coimbatore	0.06	0.05	739
Salem	0.01	0.004	465
Dharmapuri	0.02	-	-

Table : 11 Improved pulses varieties

S. No	Variety	Year of release	Duration (days)	Yield Kg/ha Rainfed	Irrigated	Special characteristics	Area of adaptation
REDGRAM							
1	Vamban 2	1999	180	1050	-	Resistant to sterility mosaic disease. Suitable as a rainfed crop in mixed and intercropping situations to replace SA 1 and CO 6	Entire Tamil Nadu
2	CO 5	1985	120-130	800	1500	Photoinsensitive moderately resistant to podfly, root rot sterility mosaic disease	Entire Tamil Nadu
3	Vamban 1	1992	95-100	840	1200	Highly suitable for intercropping in groundnut.	Vellore, Tiruvannamalai, Pudukottai, Madurai, Sivagangai, Tirunelveli, Virudhunagar, Theni, Ramanathapuram
4	Arupukottai (APK 1)	1999	95-105	900	1250	Suitable as a pure crop in irrigated conditions. Resistant to SMD	Virudhunagar, Ramanathapuram, Sivagangai, Madurai, Theni, Tuticorin, Tirunelveli, Trichy, Salem, Dharmapuri, Coimbatore.
5	COPH 2	1997	120-130	1050	1350	Suitable as a pure crop in irrigated conditions and suitable for rainfed situations also. Good synchronisation for seed production and resistant to SMD	Coimbatore, Erode, Salem, Dharmapuri, Vellore, Tiruvannamalai, Trichy.

BLACKGRAM							
6	CO 5	1981	70-75	750	1250	Moderately resistant to powdery mildew, leaf crinkle, pod borer and tip blight but susceptible to YMV	Coimbatore, Erode, Salem, Dharmapuri, Vellore, Tiruvannamalai
7	Vamban 1	1987	65	780	900	High yielding and resistant to YMV. Suitable for both irrigated and rainfed conditions	Ramnad, Pudukottai, Tirunelveli, Vellore.Tiruvanna malai, Tuticorin, Madurai, Trichy
8	Vamban 2	1996	65	700	1100	Suitable for both rainfed & irrigated conditions. Resistant to YMV.	Ramnad, Pudukottai, Tirunelveli, Vellore,Tiruvanna malai, Tuticorin, Madurai, Trichy
9	Vamban 3	2000	70	825	950	Suitable for both rainfed & irrigated conditions. Resistant to YMV.	Entire Tamil Nadu
10	K 1	1994	70-75	700	-	Suited to Southern districts. Suited for intercropping with cotton.	Southern districts for intercropping with Cotton
GREENGRAM							
11	CO 6	1999	65-70	850	1300	Resistant to YMV. Suited to both rainfed and irrigated conditions	Entire Tamil Nadu
12	Paiyur 1	1988	85-90	700	-	Suitable for rainfed conditions in Dharmapuri and Salem districts low incidence of YMV	Dharmapuri & Salem districts
13	Vamban 1	1989	70	800	-	Suitable for rainfed conditions in Southern districts	Pudukottai, Madurai, Trichy, Tirunelveli and Tuticorin
14	K 1	1998	70-75	700	-	Suitable for Cotton based intercropping because of short duration and short stature.	Suitable for intercropping with Cotton for southern districts

COWPEA							
15	CO 4	1983	85	960	1570	*Seed colour greenish* brown. Suited for irrigated conditions. High yielding.	Coimbatore, Erode, Salem, Dharmapuri, Vellore and Tiruvannamalai
16	CO 6	1993	65-70	700	-	Highly suitable for rainfed conditions. Shortest duration. Resistant to rust disease. Seed colour light cream. Good marketability	Coimbatore, Erode, Salem, Dharmapuri, Vellore and Tiruvannamalai
17	Paiyur 1	1985	90	750	-	Suited to rainfed condition of Dharmapuri and Salem districts	Suited to Dharmapuri and Salem districts.
18	Vamban 1	1997	65	950	-	Suited to rainfed conditions. White grain.	Suited to Pudukottai, Trichy, Madurai, Vellore and Tiruvannamalai
19	Vamban 2	1998	85	10.6 tons *Green* pods	-	Vegetable types lengthty, fleshy pods.	Entire Tamil Nadu
20	CO 2	1972	90	11.0 tons Green pods	-	Vegetable type, lengthy, fleshy pods.	Entire Tamil Nadu
HORSEGRAM							
21	CO 1	1953	110	600	-	Suited to rainfed condition	Suited to Coimbatore and Erode districts
22	Paiyur 1	1988	110	650	-	Suited to rainfed condition	Suited to Dharmapuri and Salem districts
23	Paiyur 2	1998	105	870	-	High protein (19.25%) suited for Samai, Groundnut, Gingelly - Horsegram crop *sequences in rainfed* lands	Suited to Dharmapuri and Salem districts

BENGALGRAM							
24	CO 3	1986	85	1000	-	Tolerant to root rot and wilt	Suited to Coimbatore, Salem and Dharmapuri districts
25	CO 4	1998	85	1150	-	Attractive Desi bold grains. 30 - 32 g. 100 seed weight and tolerant to root rot.	Suited to Coimbatore, Salem and Dharmapuri districts
SOYBEAN							
26	CO 1	1980	85	-	1600	Erect, bushy determinate photoinsensitive.	Entire Tamil Nadu
27	CO 2	1995	75-80	-	1350	Photoinsensitive,tolerant to YMV and leaf minor. Suited to intercropping	Entire Tamil Nadu
28	ADT 1	1990	85	-	1270 (rice fallow)	Suitable for rice fallow situations where there is no terminal moisture stress and high temperature.	Suited to Tanjore, Tiruvarur, Nagapattinam, Cuddalore and Trichy
RICE FALLOW PULSES BLACKGRAM							
29	ADT 2	1979	70-75	600	-	Highest protein content (21.5%)	Thanjavur, Nagapattinam, Tiruvarur, Trichy, Cuddalore, Tirunelveli, Tuticorin.
30	ADT 3	1981	70-75	750	-	Suited for raising in field bunds	Thanjavur, Nagapattinam, Tiruvarur, Trichy, Cuddalore, Tirunelveli, Tuticorin.
31	ADT 4	1987	65-70	1000	-	Synchronised flowering and maturity and suited for bund cropping.	Thanjavur, Nagapattinam, Tiruvarur, Trichy, Cuddalore, Tirunelveli, Tuticorin.

32	ADT 5	1988	70-75	1550 (irrigated summer)	-	Very high yielder. Flowering behaviour according to moisture availability.	Pudukottai, Orthanad areas summer, kharif irrigated situations 2 to 3 flushes.
GREENGRAM							
33	ADT 2	1982	70	800	-	Resistant to powdery mildew	Thanjavur, Nagapattinam, Tiruvarur, Trichy, Cuddalore, Tirunelveli, Tuticorin
34	ADT 3	1988	70	850	-	Resistant to stemfly	Thanjavur, Nagapattinam, Tiruvarur, Trichy, Cuddalore, Tirunelveli, Tuticorin.

PROCEEDINGS OF THE GROUP MEETING ON TECHNOLOGIES ORIENTED PULSE PRODUCTION

The session was chaired by Dr.C.Surendran, Director, Centre for Plant Breeding and Genetics and Thiru.K.Seerangan, Joint Director of Agriculture, Salem was the Co-Chairman. Dr.K.Mohana Sundaram Professor and Head, NPRC, Vamban and Dr.T.S.Raveendran, Professor and Head, Department of Cotton were the Rapporteurs. The session was attended by 34 members including the scientists and officers of Development Departments.

The Chairman presented the production technologies of pulses developed so far and highlighted the following points.

1. APK 1 short duration (100-105 days) redgram variety having resistance to SMD may be adopted in the place of Vamban 1. The variety CO 5 and hybrid COPH 2 (medium duration of 120-130 days) are recommended. Vamban 2 is a long duration variety having resistance to SMD is an alternate to SA 1 and CO 6.
2. In blackgram, the variety VBN 3 with YMD resistance and ADT 5 need popularisation as a replacement for TMV 1, T9, VBN 1 and VBN 2. Similarly the greengram variety CO 6 deserves popularisation in view of its resistance to YMV as a replacement for KM 2. For rice fallow pulses, Blackgram varieties ADT 2 and ADT 3 and Greengram ADT 2 and ADT 3 are the best varieties.
3. The new variety in Horse gram Paiyur 2 with high protein and cowpea CO 6 having resistance to rust disease and Vamban 1 for grain purpose and the vegetable cowpea varieties CO 2 and Vamban 2, CO 4 Bengalgram tolerant to root rot, soybean CO 2 tolerant to YMV and leaf miner may be spread among the farmers.
4. To maintain population under rice fallow conditions, adopt higher seed rate.
5. Time of sowing for rice fallow pulses shall be between Jan-15 & Feb 15.
6. Spraying 2% DAP twice, one at the time of flowering and the next after 15 days.
7. Optimum plant stand for blackgram and greengram (33 plants/sq m)and redgram (11 plants/sq m).
8. Specific rhizobium strains treatment (600 g/ha as seed treatment.).
9. Phosphobacteria application (600 g/ha as seed treatment)
10. Sulphur application through gypsum (40 Kg/ha) in sulphur deficient soils.
11. Adoption of IPM technologies to control pod borer in redgram.

He also presented the statistics, which revealed that the global pulses productivity is 807 Kg/ha while Indian national average is only 650 kg/ha. He expressed with deep concen that the Tamil Nadu average is still lower which is 450 Kg/ha. Therefore modern technologies should aim at improving our State average yield atleast to the level of national average.

The following recommendations have emanated from the discussions.

1. Varieties recommended for popularisation.

Redgram : APK 1, CO 5, COPH 2 (Hybrid) and Vamban 2

Blackgram : Vamban 3, ADT 2, ADT 3, ADT 5
Green gram : CO 6, ADT 2 and ADT 3
Horsegram : Paiyur 2
Cowpea : CO 6, Vamban 1 (Grain), CO 2 and Vamban 2(Vegetable)
Bengalgram : CO 4
Soybean : CO 2

2. Necessary modification in the groundnut seed drill may be provided to accommodate redgram seeds for sowing as an intercrop.
3. A redgram variety with synchronous maturity to accomplish single harvest may be evolved.
4. Necessary changes in the crop production manual to correct the seed rate for rice fallow pulses as 30 Kg/ha instead of 20 Kg/ha have to be made
5. The black gram varieties viz., VBN 1, 2, 3 may be popularised in the place of TMV 1, T9 etc. which are susceptible to YMV.
6. The technologies like application of *Rhizobium*, *Phosphobacteria*, *Trichoderma viridae* need popularisation.
7. A separate seed corporation as existing in Karnataka and Maharastra may be started in Tamil Nadu.

DISCUSSION

Joint Director of Agriculture, Salem
1. Adequate quantity of breeder seeds of redgram variety Vamban 2 needs to be produced.

Professor and Head (NPRC), Vamban
A total of 160 Kg of breeder seeds of redgram Vamban 2 was produced and supplied to the Joint Directors of Agriculture this year. Besides 170 Kg of truthful seeds were also produced and supplied. These seeds may be used for multiplication of adequate quantities of certified and truthful seeds required to the farmers.

Joint Director of Agriculture, Salem
2. Co 5 greengram is better yielding than other varieties but only problem is its susceptibility to YMV.

Professor (Plant Pathology), CPPS
The recommendation of application of *Pseudomonas fluorescens* as seed treatment at 10 g/kg of seeds is able to control YMV upto 45 days.

Professor of Biochemistry
Molecular work would be able to solve the problem of YMV disease which is in its early stage of research.

Joint Director of Agriculture, Salem
3. Redgram is raised predominently as an intercrop in groundnut. The groundnut seed drill is very much popular among the farmers and provision for sowing the intercrop of redgram in the seed drill may enable simultaneous sowing of the main and intercrop.

Professor and Head, Agricultural Processing, TNAU
Groundnut seed drill will be suitably modified to provide a separate compartment for sowing redgram as an intercrop.

Joint Director of Agriculture, Vellore
4. TNAU should developed Greengram and Cowpea varieties with synchronised maturity for one time harvesting and possessing complete resistance to YMV.

Professor and Head, AC&RI, Trichy
Development of cowpea and greengram varieties with synchronous maturity cannot

be achieved due to genetic architecture of the material.

Dean, AC&RI, Killikulam
YMV is transmitted only through white fly. The whitefly vector for YMV, multiplies as temperature increases and the intensity of YMV also goes up with the increase in the whitefly population.

The blackgram varieties VBN 1, VBN 2, VBN 3 which harbour less whitefly population results in low YMV incidence (less than 5%).

Joint Director of Agriculture, Vellore
5. Cultivation of pulses is not economical and the seed production plots of pulses will not give profitable return.

Dean, AC&RI, Trichy
It is very difficult to work out the economics of seed production, as the pulses cultivation is restricted only to very marginal lands and in lands where other crops couldn't be cultivated. The inputs applied are also very minimum.

Professor and Head, AC&RI, Trichy
The seed production plots should be raised in highly fertile area so as to get maximum seed output and net profit.

Joint Director of Agriculture, Pudukkottai
6. The pulses should be treated as a commercial crop and should be raised in highly fertile lands with high inputs. The duration of blackgram should also be simultaneously increased so that the productivity could be increased and the genotype so developed should withstand the drought.

Professor and Head, NPRC, Vamban
Available germplasm will be screened for identifying an ideal genotype as needed.

Joint Director of Agriculture, Salem
7. Whether VBN 2 redgram can tolerate drought like SA 1.

Professor and Head, NPRC, Vamban
Vamban 2 redgram also tolerates drought and rejuvenates with on set of the rains to and produce better yield than SA 1.

Joint Director of Agriculture, Vellore
8. The redgram variety ICPL 87119 sown on 27.1.2000 has not flowered till date.

Professor and Head, NPRC, Vamban
The variety is photo sensitive in nature developed from ICRISAT. It should be sown only during June. The standing plants may be pruned to a height of 40 cm and should be supplied with nitrogen so that the crop will flower during September.

Professor and Head (Ag.Bot.) AC&RI, Trichy
Sowing of redgram at 1.5 m or at 2 m interval along with groundnut as intercropping will give better groundnut as well as redgram yield.

The Deputy Director, Thiruvarur
9.The pulses for rice fallow tract which will withstand both drought and water logging conditions may be evolved.

Associate Professor, Seed Science and Technology, TNAU
Seed hardening technique will help to increase the seed germination upto 80%.

Joint Director of Agriculture, Cuddalore
10. Application of 2% DAP to dry land pulses as recommended in the crop production manual is very difficult since in dry land water is not available for spraying due to acute drought. What is the alternative?

Associate Professor (Agronomy)
This technique is recommended only wherever water is available for spraying.

Joint Director of Agriculture, Cuddalore
11. The requirement of seed rate for rice fallow pulses is 30 kg/ha, but in the crop production manual, it is recommended as 20 Kg/ha. Please suggest necessary corrections in the crop production manual.

The Director, Centre for Plant Breeding and Genetics
Necessary amendments will be suggested for incorporation in the crop production manual.

Joint Director of Agriculture (Pulses)
12. The pod borer problem is very serious in redgram. The breeders should evolve a variety resistant to pod borer.

The Director, Centre for Plant Breeding and Genetics
The evolution of a resistant variety for pod borer in redgram is very difficult because no resistance / tolerance is available and the pest *Helicovarpa* is a polyphagous insect. However attempts will be made for developing pod borer resistant variety. Till then CO 6 which is tolerant to pod borer may be used.

Secretary, Agriculture
13. Why breeding for resistance to pod borer is very difficult?
If suitable donrs are not available in cultivated species why don't you bring wild species for incorporation of resistance?

Dean, AC & RI, Madurai.
There are no resistant varieties of redgram available in the cultivated species. However a few wild species exhibit resistance. These wild species also contain other undesirable characters like bitter taste. Hence transfer of resistance is very difficult. However attempts will be made for utilisation of wild species in the crossing programme to incorporate resistance to pod borer.

Joint Director of Agriculture, Vellore
14. Suitable measures can be evolved to contained the bruchids infestation.

Associate Professor, Entomology, CPPS
We have devloped some techniques for controlling an important stage of the bruchids. Spraying of endosulfan to the standing crop 10 days before harvest will destroy the egg masses of bruchids and controls bruchid infestation upto 6 months.

Deputy Director of Agriculture, Thiruvarur
15. When we are talking about IPM which is not achievable, we are going for chemicals sprays. Instead of that some botanicals may be tried.

Professor and Head, Agricultural Processing
We have already developed a technique of fumigating the containers as well as pulse seeds. Mixing the seeds with dried and powdered leaves of pungum / neem / nochi / adathodai at 1:100 ratio will keep the seeds free from bruchids for 6 months.

Joint Director of Agriculture, Vellore
16. We are getting only common bacterial cultures for all pulses and crop specific strains are not made available for distribution.

Associate Professor (Microbiology)
Every year, specific strains are identified and upgraded version of *Rhizobium* and *Phosphobacteria* are produced and supplied. One pocket each in *Rhizobium* and *Phosphobacteria* for 10

Kg of pulses will be useful to increase the yield level of the crop.

The Director, Centre for Plant Breeding and Genetics

We will recommend production of specific bacterial cultures on different pulses crop and will supply the same to the Department on request.

The Joint Directors of Agriculture, Pudukottai, Cuddalore, & Vellore and JDA (Pulses)

17. Modalities for production of hybrid seeds have to be worked out, setting up of a separate seed corporation as in Karnataka and Maharastra may be recommended.

Professor and Head (Ag.Bot.), Trichy

A workable seed production unit to establish a continuous link in seed production has to be formulated.

The house felt the following important recommendations are to be included.

1. The hybrid technology should be taken to the farmers to increase the yield level of redgram.
2. The technologies of application of *Rhizobium*, *Phosphobacteria*, *Trichoderma viridae* and seed treatment needs popularisation.

MAIZE PRODUCTION TECHNOLOGIES

Surendran
S.KANNAIYAN, C.~~SUBRAMANIAN~~, N.SUBBARAMAN AND G.NALLATHAMBI

Maize (*Zea mays*) is one of the third most important cereals, next to wheat and rice, in the world agriculture with respect to both area and productivity. It is one of the most versatile crop and can be grown over a diverse environmental conditions. It has highest yield potential than other millets and has diversified uses in human food, animal feed and as a source of large number of industrial products. This crop is used to a higher level of industrial utilization than any other cereal grain because of its very high production potential, wider adaptability and having specific industrial value. The uses of maize include corn oil, syrup, starch, dextrose, beverage, pharmaceuticals, poultry feed and many others.

Globally, maize is grown in more than 130 countries. According to the FAO Year book 1996, world production of maize during 1995 amounted to 514.51 million tonnes with yielding capacity of 3776 kg/ha, accounting 63.9 per cent of the coarse grains and 27.1 per cent of the total cereals production respectively.

Table : 1 Area, production and productivity of important maize growing countries in the world (1994)

Sl. No.	Country	Area (mi.ha.)	Production (mi.tonnes)	Productivity (Kg/ha)
1.	Asia	38.34	131.16	3654
2.	China	20.58	103.55	5033
3.	India	6.10	10.50	1750
4.	Philippines	3.14	5.40	1722
5.	Indonesia	3.04	6.62	2177
6.	Thailand	1.20	3.80	3167
7.	Turkey	0.45	1.85	4111
8.	Vietnam	0.53	0.95	1792
9.	North America	40.50	286.27	7067
10.	Canada	0.95	7.04	7375
11.	Mexico	7.85	19.19	2444
12.	USA	29.50	256.63	8697
13.	South America	18.65	47.89	2568
14.	Brazil	13.74	32.30	2350
15.	Africa	21.32	37.83	1775
16.	Europe	10.97	53.90	4914
17.	France	1.67	13.04	7827
18.	Hungary	1.26	4.92	3892
19.	Romania	2.99	9.30	3110
20.	Yugoslavia	1.40	4.86	3471
	World	131.53	569.56	4330

Maize scenario in India

Maize is successfully cultivated under varying environmental conditions throughout the country especially during *kharif*, *rabi* and summer seasons. Among cereals, maize ranks fifth in total area, fourth in total production and third in yield per hectare in India. Maize occupies an area of 6.1 million ha with an annual production of 10.7 million tonnes (1998-99). In the early days, the productivity of maize crop in India was only 600 kg/ha and at present, the average productivity is 1620 kg/ha (1998-99). This level of production has to be substantially raised to meet its growing demand for human food, animal and poultry feed as well as for industrial processing by the wet and dry millers to produce value added products.

Potential winter maize growing states have been identified as Bihar, Uttar Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra and Orissa. More surprisingly, the state of Karnataka with almost cent per cent adoption of modern maize ranked first in its yield realization till 1997-98 (2984 kg/ha), now lagging behind Andhra Pradesh. Another noticeable fact is that Uttar Pradesh, Rajasthan, Madhya Pradesh and Bihar (Kharif season) , together accounting for 50 per cent to the total maize area, still do not use improved technologies and the productivity of maize in these states remained at low level.

Table : 2 Area, production and productivity of important maize growing states in India (1997 – 98)

Sl.No.	State	Area (la.ha.)	Production (la.Tonnes)	Productivity (Kg/ha)
1.	**Uttar Pradesh**	10.74	16.57	1543
2.	Bihar	6.90	11.75	1703
3.	Rajasthan	9.64	12.17	1263
4.	Madhya Pradesh	8.34	11.00	1318
5.	Punjab	1.68	3.52	2095
6.	Jammu & Kashmir	3.10	4.41	1422
7.	Gujarat	3.99	6.58	1650
8.	Himachal Pradesh	3.12	6.21	1990
9.	**Andhra Pradesh**	3.96	10.84	2737
10.	Haryana	0.24	0.46	1917
11.	Orissa	0.52	0.64	1228
12.	Karnataka	5.59	16.69	2984
13.	West Bengal	0.46	1.30	2698
14.	Maharashtra	2.41	2.98	1234
15.	Tamil Nadu	0.82	1.33	1625
16.	Meghalaya	0.17	0.30	1448
17.	Assam	0.19	0.15	766
18.	Arunachal Pradesh	0.34	0.50	1449
19.	Nagaland	0.30	0.30	1000
20.	Sikkim	0.39	0.56	1414
	Total	63.03	10.85	1722

Table : 3 Area, production and productivity of maize in India (1986-87 to 1997-1998)

Year	Area (mi.ha)	Production (mi.t)	Productivity (kg/ha)
1986 - 1987	5.92	7.60	1275
1987 - 1988	5.54	5.63	1250
1988 - 1989	5.90	8.23	1491
1989 - 1990	5.86	9.54	1606
1990 - 1991	5.95	9.07	1524
1991 - 1992	5.78	7.98	1381
1992 - 1993	6.02	10.21	1694
1993 - 1994	6.13	9.65	1574
1994 - 1995	6.10	9.12	1493
1995 - 1996	6.01	9.44	1560
1996 - 1997	6.26	10.33	1681
1997 - 1998	6.30	10.85	1721

Scope of maize cultivation in Tamil Nadu

In Tamil Nadu, coarse cereals area is being gradually reduced every year which is due to the change of food habits of the rural populations and switching over to remunerative crops l like sugarcane, banana, turmeric, vegetable and floriculture cultivation. But the area under maize is in increasing trend due to its greater demand for poultry and animal feed industries and also better price than other coarse cereals.

Table : 4 Area, production and productivity of maize in Tamil Nadu (1986-87 to 1997-1998)

Year	Area (la.ha)	Production (la.t)	Productivity (kg/ha)	All India rank
1986 - 1987	0.296	0.459	1550	4
1987 - 1988	0.205	0.315	1890	3
1988 - 1989	0.327	0.472	1443	6
1989 - 1990	0.413	0.598	1448	10
1990 - 1991	0.249	0.374	1503	7
1991 - 1992	0.354	0.518	1462	9
1992 - 1993	0.498	0.744	1494	13
1993 - 1994	0.700	0.799	1628	9
1994 - 1995	0.669	1.085	1622	10
1995 - 1996	0.552	0.870	1577	7
1996 - 1997	0.672	1.072	2178	8
1997 - 1998	0.820	1.332	1625	9

In Tamil Nadu, maize did not occupy a larger area till 1968, but its area is steadily increasing for the past 25 years. The crop was grown over an area of 0.13 lac ha during 1969-70 with the annual production of 0.14 lac tonnes, mainly concentrated in Tanjore, Pudukkottai and Trichy districts. Due to rapid expansion of poultry industries and popularization of high yielding hybrids such as Ganga 5, Ganga 11, Deccan, COH 1 and Composite CO 1, the area under maize in Tamil Nadu has gone up to 0.22 lac ha during 1985-86. Similarly, the average productivity has also increased from 1078 kg/ha (1969-70) to 2226 kg/ha (1985-86). Currently, maize is cultivated in an area of 0.82 lac ha with a production of 1.33 lac tonnes with the productivity of 1625 kg/ha (1997-98). At present, the cultivable area under maize is estimated to be more than 1.0 lac ha.

The major maize growing districts are Dindigul, Coimbatore, Erode, Karur, Perambalur and Salem and smaller area in southern districts of Tamil Nadu. Seventy per cent of the total area of maize is occupied only in Dindigul district. In the year 1990-91, the maize area of this district was only 5,500 ha and at present, the area of kharif maize is alone 45,000 ha. and rabi maize is 25,000 ha. In this district, 95-98 per cent of the area is covered mostly by hybrid maize and the seeds are supplied by private and public sectors. The average productivity of this district alone is 4.5 t/ha in kharif maize (Sep-Oct-Rainfed) and 3.9 t/ha in rabi maize (Dec-Jan-Irrigated)

In the western zone of Tamil Nadu (Coimbatore, Dindigul, Erode and Trichencode taluk of Salem), three crops are possible in a year, (June – July ; September - October and December - January). Whereas, in North western zone (Dharmapuri, Salem and Perambalur), north eastern zone (Chengalpet, Cuddalore, Thiruvannamalai, Vellore) and southern zone (Pudukkottai, Tirunelveli, Tuticorin, Virudhunagar and Madurai), only two crops are possible in a year (June – July and Dec - Jan). Maize is known to be very responsive to better management. Therefore, special strategic planning is needed to encourage maize cultivation in the state as a whole .

Due to the gradual increase in the demand of maize for poultry and animal feed industries and for industrial uses, maize is expected to influence our agriculture to a great extent. The success and the level of profit of maize crop predominently depends on the adoption of improved hybrid/composite with good management practices.

(I) Crop Improvement Technologies

The research for maize improvement in the state of Tamil Nadu aimed at the development of high yielding hybrids/composites coupled with downy mildew disease resistance.

(a) CO 1 composite

The maize CO 1 is a composite developed by unit selection by utilizing Suwan - 1 population, which was released in the year 1985, incorporated with a very high resistance to downy mildew and with good grain yield. It matures in 105 to 110 days. It gives an average yield of 5200 kg/ha in irrigated and 3300 kg/ha in rainfed

situations. It is commonly grown in Coimbatore, Erode, Salem and Pudukkottai districts. It is suitable for cultivation as both grain and fodder.

(b) Hybrid COH 2

It is a single cross hybrid involving UMI 810 as a female inbred and UMI 90 as a male inbred. It was released in the year 1989 for general cultivation in maize growing districts of Tamil Nadu. It matures in 95 to 100 days. The grains are bold, yellow in colour and flint in texture and are acceptable to consumers. It is suited for both irrigated (5400 kg/ha.) and rainfed (3500 kg/ha.) situations. This hybrid is resistant to sorghum downy mildew and also tolerant to drought.

(c) Hybrid COH 3

It is a double cross hybrid (UMI 101 x UMI 130) X (UMI 90 x UMI 285), released in the year 1996 for general cultivation in Tamil Nadu. It matures in 95 to 100 days. This hybrid is suited for cultivation under both rainfed (4200 kg/ha.) and irrigated (6000 kg/ha.) conditions. It has an yield potential of 8875 kg of grain and 19 tonnes of fodder per hectare. This hybrid is highly resistant to downy mildew disease and stem borer. It possesses desirable attributes such as high starch (64.80 %), high protein (11.03 %) and high oil content (4.85 %) than COH 2 (63.0 % starch, 10.10 % protein and 4.54 % oil) and CO 1 (63.0 % starch, 10.57 % protein and 4.83 % oil). The grains are bold, orange yellow in colour and flint in texture. The cobs are fully covered with husk and the percentage of seed set is very high.

(d) Baby corn COBC 1

Baby corn is the tender cob of the maize plant and it is harvested when the silks have just emerged (1-3 cm) before fertilization. COBC 1 is producing 2 to 3 cobs per plant and these tender cobs are then dehusked and used as such for green cob consumption and for various dessert purposes. It is suited for cultivation both under rainfed (June – July and Sep - Oct) and throughout the year under irrigated conditions.

Baby corn COBC 1 is a composite developed by unit selection involving UMI 836 as base material, by combining with related populations of UMI 836-1-2. It was released in the year 1998. It has a duration of 50 - 65 days for baby corn production of (6660 kg/ha.), 65 - 70 days for green fodder (32.2 t/ha.) and 100 - 105 days for seed (2000 kg/ha). It has an yield potential of 8316 kg of baby corn per hectare.

COBC 1 is moderately resistant to downy mildew disease and is tolerant to major pests of maize. Its tender cobs possesses desirable attributes such as high starch (7.1 %) and delightful sweet flavour (total sugars 1.3 %) than BC local (starch 6.5 %, total sugar 1.0 %) It act as a valuable nutritious energy source vegetable and is having attractive standard size cob (9 - 10 cm) suited for export market. The kernels are arranged in straight rows, yellow in colour with dent texture. The new baby corn COBC 1 is also recommended for home gardens and commercial cultivation in the state of Tamil Nadu. It should be grown in isolation and all other practices are similar to maize composite seed production.

II. CROP MANAGEMENT TECHNOLOGIES

Irrigated Maize

1. Field Preparation

Plough twice with an iron plough or three or four times with a country plough. In between the ploughing, break the clods, if necessary, or plough six times with a country plough till a fine tilth is obtained.

2. Application of FYM or compost

Spread 12.5 t/ha of FYM or composted coir pith evenly on the unploughed field along with 10 packets of Azospirillum (2000g/ha) and incorporate in the soil.

3. Forming ridges and furrows or beds

a. Form ridges and furrows, 6m long and 60 cm apart
b. Form irrigation channels across the furrows
c. If ridges and furrows are not made, form beds of size $10m^2$ or $20m^2$ depending on the availability of water
d. Use a bund former or ridge plough to economise the cost of production.

4. Application of fertilizers

a. Apply NPK fertilizers as per the soil test recommendation. If soil test recommendation is not available, adopt 135 : 62.5 : 50 NPK kg/ha.
b. Apply 1/4 of the dose of N and full dose of P_2O_5 and K_2O basally before sowing.
c. In the case of ridge planted crop, open a furrow 6 cm deep on the side of the ridge at two thirds the distance from the top of the ridge.
d. Place the fertilizer mixture along the furrows evenly and cover to a depth of 4 cm with soil.
e. When Azospirillum is used as seed and soil application, apply 100 kg of N/ha. (25 % reduction on the total N)

5. Application of micronutrient

12.5 kg of micronutrient mixed with sand to make a total quantity of 50 kg/ha is to be applied. Do not incorporate the mixture in the soil.

MANAGEMENT OF MAIN FIELD

Seed rate and sowing

Hybrids - 15 kg/ha ; Varieties - 20 kg/ha
Dibble the seeds at a depth of 4 cm and cover with soil
Spacing - 60 cm X 20 cm

Weed management

Apply pre-emergence herbicide, Atrazine @ 500 g/ha (900 litres of water) 3 days after sowing. For maize + soybean intercropping system, apply pre-emergence herbicide Alachlor 4.0 l/ha or Pendemethalin 3.3 l/ha on 3rd day after sowing when there is sufficient moisture. Do not disturb the soil after herbicide application. If pulse crop is used as intercrop, avoid using Atrazine.

Thinning and Gap filling

Leave only one healthy and vigorous seedling per hole and remove other seedlings on 8th day of sowing.

Hoeing and Earthing up

Hoe and hand weed on the 30th day of sowing , earth up and form new ridges to provide anchorage to the plants.

Top dressing of fertilizers

Place half dose of N on the 25th day of sowing along the furrows and cover with soil. Place the remaining dose of N on the 45th day of planting and cover with soil.

Yield Maximisation

Adopt a plant population of 1,11,000 plants (60 X 15 cm) with NPK 200 : 100 : 80 kg/ha. Apply N and K in three equal splits at sowing, knee high and tasselling stages. Apply $ZnSO_4$ @ 25 kg/ha as basal in addition to other recommended practices.

RAINFED MAIZE

Field Preparation

Chisel the soil having hard pan at 0.5m interval first in one direction and then in the direction perpendicular to the previous one once in three years. Apply 12.5 t/ha of FYM or compost or composted coir pith to get additional yield of about 30% over control.

Application of fertilizer

Apply NPK as per the soil test recommendation. If not, adopt a blanket recommendation of 60 : 60 : 30 NPK kg/ha for alfisols and 40 : 20 : 0 NPK kg/ha for vertisols. Apply 1/2 of N and full dose of P_2O_5 and K_2O with enriched FYM as basal along with Azospirillum (10 Packets/ha). Top dress the remaining half of N at tasselling.

Seed rate

Hybrid - 15 kg/ha ; Varieties - 20 kg/ha

Spacing

Adopt a spacing of 45 X 20 cm to have a population of 1,11,000 plants/ha

Cropping systems

Intercropping system of maize + cowpea or maize + blackgram is recommended for higher net returns in the red lateritic soils of southern districts

For vertisols of Southern listricts, maize + redgram intercropping system is ideal.

(III)CROP PROTECTION TECHNOLOGIES

A) Disease management

Maize is affected by fungal, bacterial, viral diseases from the seedling stage to the harvesting stage. In Tamil Nadu, the fungal diseases like downy mildew, leaf blight and r flowering stalk rot are the major problems which cause severe yield loss.

(a) Downy Mildew

This disease is caused by the fungus *Perenosclerospora sorghi* . It infects the young seedlings and grow systemically in plants and reduce the yield. Low temperature (21 - 23 C), high relative humidity (90 %), water logging and light drizzling favour the development of this disease.

Symptoms

1. Affected plants produce thin short internode, small chlorotic leaves with bushy appearance.
2. White, velvetty downy growth on the lower surface of leaf and corresponding upper surface shows yellow chlorotic streak.
3. Tassels become malformed with green leafy structures and appear as bunchy.
4. Cob size and grain filling is affected.

(b) Leaf Blight

This disease is caused by the fungus *Helminthosporium turcicum*. It occurs at the young stage, early in the wet season.

Symptoms

1. Small, yellowish round to oval spots are seen in the leaves.
2. The spots gradually increase in size into bigger spots and are straw to greyish brown colour in the centre with dark brown margin.
3. The spots coalesce to form bigger spots and give blighted appearance.
4. Severely infected field shows burnt appearance

(b) Post flowering stalk rot

It is caused by the fungus *Macrophomina phaseolina*. The disease occurs at the time of cob formation and its development. High temperature and drought favour the disease development.

Symptoms

1. Wilting of affected plants.
2. Greyish streaks on the stalk which becomes weak.
3. Shredding of pith, root bark and disintegration of root system.
4. Silk and tassel development is completely arrested.

INTEGRATEDDISEASE MANAGEMENT

1. Deep summer ploughing to destroy the soil borne pathogens.
2. Crop rotation with non-host crop to manage the downy mildew and post flowering stalk rot.
3. Removal of infected plants and keep the field clean.
4. Removal of weeds, alternative hosts which are harbouring the disease causing organism.
5. Growing resistant varieties *viz.*, CO.1, COH.2, COH 3 in downy mildew endemic areas.
6. Seed treatment with fungicides

Treat the seeds with Carbendazim or Thiram @ 2g/kg of seeds to control the seed and soil borne pathogens.

7. Foliar spray of fungicides

To control the downy mildew disease, spray Mancozeb @ 1.25 kg/ha as and when the incidence is noticed.

To control the leaf spot, spray Mancozeb or Captan @ 1.25 kg/ha, when the disease intensity reaches grade 3.

B) Pest management

Insect problems in maize start at seedling stage and continue till harvest. Introduction of high yielding varieties and monoculture favoured some of the insect pests to assume pest status and cause economic yield loss. More than a dozen of insect pests have been recorded on maize, the major ones are being stem borers and cob borers.

(a) Stem borers *(Chilo partellus and Sesamia inferens)*

Young larvae bore into the leaf whorls and cause shot holes. They also feed on the leaves by scrapping and some times bore into midrib. Then the larvae migrate to the base of the plant, bore into the shoot and damage the growing point resulting in production of deadheart. Larvae continue to feed inside the stem till harvest. Extensive tunnelling in the stem results in loss of vigour and such affected plants putforth weak earheads

Light traps can be set up to attract and kill the adult moths. After harvest, the stubbles should be collected and destroyed. Application of granular insecticides *viz.*, quinalphos 5G 15 kg/ha or carbaryl 4G 20 kg/ha mixed with sand (Total volume 50 kg) in the whorls on 20 days after sowing effectively control the stem borers.

(b) Cob borers *(Helicoverpa armigera and Cryptoblabes gnidiella)*

Larvae bore into the cob and feed on the developing grains resulting in heavy yield loss. The larvae can be hand picked and destroyed. The light trap and pheromone traps can be installed to attract and kill the adult moths. Spraying of carbaryl 50WP 1.0 kg/ha or dusting of carbaryl10% dust 25kg/ha effectively suppress the infestation.

(c) Shoot fly *(Atherigona orientalis)*

Affects the crop in the seedling stage. The maggots bore into the plant and feed on the growing point. As a result of this, central shoot dries up forming deadheart.

(d) Sucking pests *(Perigrinus maidis and Rhopalosiphum maidis)*

The shoot bug *P.maidis* suck the sap from leaf whorls and between leaf sheath and stem. The damaged plants become stunted. The aphid *R. maidis* sucks the sap from the whorl leaves. It also transmits the maize mosaic virus.

(e) Leaf feeders *(Mythimna separata, Spodoptera exigua, Agrotis ipsilon and Hieroglyphus nigrorepletus)*

The army worms *(M.separata, S. exigua)*, cut worm *(A.ipsilon)* and grass hopper *(H. nigrorepletus)* feed on the leaves and cause defoliation. Generally, they do not cause severe economic loss in Tamil Nadu.

Table : 5 Maize Production Technologies

	Irrigated Maize	**Rainfed Maize**
Variety/Hybrid	Hybrid-COH 2, COH 3 Composite-CO1	Hybrid-COH 2, COH 3 Composite-CO1
Season	June-July, Jan-Feb	Sep-Oct
Duration (Days)		
COH 2	100	105
COH 3	100	105
CO 1	110	115
Seed Rate (kg/ha)		
Hybrid	15	15
Composite	20	20
Spacing (cm)	60 X 20	45 X 20
FYM/Compost (t/ha)	12.5	12.5
Azospirillum (kg/ha)	2	2
Fertilizer Schedule (NPK Kg/ha)	135 : 62.5 : 50	60 : 30 : 30 (Alfisols) 40 : 20 : 0 (Vertisols)
Pre emergence herbicide (lit/ha)	Alachlor 4.0 Pendimethalin 3.3	-
Intercultural operations		
1. 15 DAS	First weeding	First weeding
2. 30 DAS	Earthing up & top dressing (N)	Top dressing of urea based on soil moisture
3. 45 DAS	Top dressing N & K	Top dressing of urea based on soil moisture
Inter cropping	Maize + Soybean Maize + Cowpea	Maize + Cowpea Maize +Black gram Maize + Red gram
Pest Management		
Carbaryl 4G (or) quninalphos 5G (20 DAS)	20 kg/ha 15 kg/ha	20 kg/ha 15 kg/ha
Disease management		
Mancozeb or captan	1.25 kg/ha	1.25 kg/ha
Grain Yield (kg/ha)		
CO 1	5200	3300
COH 2	5400	3500
COH 3	6000	4200

Yield maximisation

To achieve the maximum yield under irrigated condition, adopt a plant population of 1,11,000 plants (60 X 15 cm) with NPK 200 : 100 : 80 kg/ha. Apply N & K in three equal splits at sowing, knee high and tasselling stages and also $ZnSO_4$ @ 25 kg/ha as basal.

Table : 6 Baby Corn Production Technologies

	Baby corn Production	Baby corn seed Production
Variety	COBC 1	COBC 1
Season Irrigated Rainfed	Throughout the year **June - July, Sep - Oct**	**June - July, Jan - Feb**
Duration	50 - 65 days (Tender cob) 65 - 70 days (Green fodder)	105 - 110 days (Seed)
Seed rate (kg/ha)	25	18
Spacing (cm)	45 X 25	60 X 25
Fertilizer schedule (NPK, kg/ha)	150 : 60 :40	135 : 62.5 : 50
Compost (t/ha)	12.5	12.5
Basal (NPK, kg/ha)	75 : 60 : 20	45 : 62.5 : 25
Top dressing (N,K) 25 DAS (kg/ha)	75 : - : 20	45 : - : -
40DAS (kg/ha)	-	45 : - : 25
Irrigation - First	After sowing	After sowing
Second	4 th day	4 th day
Third	15 th day	15 th day
Fourth	25 th day	25 th day
Fifth	35 th day	35 th day
Sixth	45 th day	45 th day
Seventh	55 th day	55 th day
Eighth	-	65 th day
Ninth	-	75 th day
Tenth	-	85 th day
Intercultural operations		
1. 15 DAS	1 st weeding	1 st weeding
2. 25 DAS	Earthing up and top dressing	Earthing up and top dressing
3. Detasselling (DAS)	Removal of male flowers 40-45	-
4. Interval for picking of tender cobs (days)	2	-
5. Number of pickings	6-7	-
6. Second top dressing DAS)	-	40 - 45
7. Tender cob/matured cob harvesting (DAS)	50 - 65	105 - 110
Plant Protection Measures		
Basal Application (kg/ha)	Furadon 3G, 10	Furadon 3G, 10
Yield (kg/ha)	Tender cob - 6660	Seed - 2000
Green fodder (t/ha)	32.2	15.0

Strategies to increase maize production in Tamil Nadu

- Double cross maize hybrid COH 3 has an yield potential of 9600kg/ha (100 days) may be popularized in maize growing areas.
- Maize composite CO 1 suitable for grain (5200 kg/ha) and fodder (30 t/ha) may be popularized in low rainfall and downy mildew endemic areas.
- Cultivation of baby corn COBC 1 (Tender cob - 6600 kg/ha, 55 - 65 days) may be encouraged as an alternate source of energy rich vegetable.
- An action plan is needed for production and distribution of
- quality hybrid seeds in right time to the farmers
- Productivity of maize crop can be enhanced by having optimum plant population (60 X 20 cm; 80,600 plants/ha)
- Application of fertilizers especially nitrogen in four splits (135 : 62.5 : 50 kg/ha, NPK) and irrigation will help to increase the productivity
- To achieve maximum yield under irrigated condition, adopt a plant population of 1,11,000 plants (60 X 15 cm) with NPK 200 : 100 : 80 kg/ha along with $ZnSO_4$, 25 kg/ha as basal.
- There is a good scope for raising rainfed maize during Sep-Oct in medium rainfall regions of Coimbatore, Erode, Salem, Dharmapuri, Dindigul, Madurai and Ramnad districts of Tamil Nadu for further increase of maize cultivation.
- Systematic organisation of onfarm research and transfer of technology is required to reach the farming community
- Efforts should be taken to promote the industrial use of maize crop in view of increasing demand which would encourage the farmers to increase its production in this state
- Projection of maize as an alternate source of edible oil
- Maize crop has an added advantage of being grown at any time of the year especially, whenever the water source is available

PROCEEDINGS OF THE GROUP MEETING ON MAIZE PRODUCTION TECHNOLOGIES

The group meeting on maize production technologies was held on 19.7.2000 from 10.00 AM to 1.00 PM at Seminal Hall of the Centre for Plant Breeding and Genetics, under the Chairmanship of Dr. P. Rangasamy, Dean (Agri), Madurai. A total of 39 participants including Th. S. Shanmugam, Additional Director of Agriculture (PPM), Chennai along with Joint Director's of Agriculture, Dindigul, Erode, Karur, Perambalur as well as Joint Director of Agriculture, SSF attended the meeting.

The Chairman in his inaugural speech highlighted the importance of maize in the Global Context as well as in India and Tamil Nadu.

- Maize has more than 300 industrial uses apart from its use as a food crop.
- It is gaining popularity in our State because of its increasing demand for the poultry and animal feed industries.
- Area under maize had tremendously increased from 21,000 ha (1990) to about 1 lakh ha (1999).
- Maize is a highly cosmopolitan crop.

Professor and Head, Department of Economics, Tamil Nadu Agricultural University gave a short account of the area, production and productivity of maize in India and Tamil Nadu and highlighted that there is a need for 18 million tonnes of maize grains in India but we are producing only 10.1 million tonnes stressing the importance to bridge the gap.

The Professor and Head, Department of Millets, presented the important maize production technologies. He highlighted the production potential of TNAU hybrids and varieties namely CO 1, COH 2, COH 3 and baby corn COBC 1, besides the management practices for irrigated and rainfed situations as well as for yield maximisation.

Maize Breeder of the Department of Millets elaborated the problems encountered in maize breeding, possibilities of baby corn cultivation in Tamil Nadu and emphasised the importance of critical periods of irrigation and nitrogen application.

The Joint Director of Agriculture, Dindigul gave a short account of maize cultivation in his district.

Director of Publications, TNAU, emphasised the importance of integrated nutrient management and suitable soils for maize cultivation. He said that the enrichment with rock phosphate would help in boosting the yield of maize.

Associate Professor, incharge of Breeder Seeds highlighted the breeder seed production of different hybrids and varieties.

Professor (Agronomy), KVK, Coimbatore shared his experience in laying out FLD in maize and emphasised that COH 3 maize hybrid is as high yielding as any other private hybrid.

DISCUSSION

Additional Director of Agriculture (PPM)
1. Only private maize hybrids alone not TNAU hybrids are available in market? What is the reason?

Professor and Head (Millets)
COH 3 a high yielding double cross maize hybrid is already available with TNAU. It is as high yielding as any other private hybrid. Commercial seed of COH 3 hybrid of 150 kg will be supplied to ADA, Dindigul to take up comparative field evaluation.

Additional Director of Agriculture (PPM)
2. Alternate methods for hand thrashing the maize cobs are essential.

Dean, Agricultural Engineering, TNAU
Dehusker cum sheller machine which can handle upto 85 quintals per day costing Rs. 45,000/- has been fabricated by TNAU. The operating cost will be only Rs. 15/- per quintal. Another maize sheller costing about Rs. 7,000/- is also available which will shell dehusked maize cob and will be very useful for small farmers. The multicrop thrashers will also be useful for thrashing maize. In addition, a weeder and tractor drawn maize seeder is also available.

Joint Director of Agriculture, Erode
3. A short duration maize variety maturing in 70 days may be evolved for intercropping in turmeric

Professor and Head (Millets)
A very short duration maize variety of 70 days will not be economically remunerative. Hence baby corn COBC 1, which can be harvested in 70 days may be tried.

In the active discussion, the following points are noted.

1. Since only private hybrids are grown on a large scale, to popularise TNAU varieties, commercial seeds should be produced on large scale and given to the farmers.
2. About 150 kg of COH 3 commercial hybrid seeds now available at the Department of Millets will be supplied to Joint Director of Agriculture, Dindigul, to take up demonstration plots and to compare it with private hybrids.
3. Another 150 kg of COH 3 commercial hybrid seeds will be used by KVK, Coimbatore for field level demonstration (FLD)
4. As the demand for seeds of pop corn and sweet corn is increasing, efforts may be made by TNAU to supply the basic seeds.
5. A short duration maize variety maturing in 70 days suitable for intercropping in turmeric is needed.
6. Field demonstrations may be held to familiarize the maize dehuskers cum shellers in different districts by Engineering division of Tamil Nadu Agricultural University, Coimbatore.

DRYLAND GREEN REVOLUTION IN TAMIL NADU – THE PERSPECTIVES

S.KANNAIYAN AND T.M.THIYAGARAJAN

Crop production in drylands is dependent entirely on natural precipitation, which is highly undependable in terms of onset, recession and distribution during the crop growing season. As the rate of growth in the irrigated agriculture has been declining, rainfed farming would inevitably has to be relied upon in the future. This demands a grater role from scientists and extension specialists to divert more concentration towards dryland agriculture, where there is larger scope for increasing the food production. Magnitude of the area and the vast hidden potential are the hopes for giving much importance to rainfed agriculture. Already this sector contributes about 44 per cent to total food production at the National level and it has to be increased further for a second green revolution.

In Tamil Nadu the dryland area spreads over to 4.1 million hectares (55% of total cultivated area) in the seven agroclimatic subzones and the distribution over seven agroclimatic subzone is 25.6 per cent in North eastern zone; 24.3 per cent in North western zone; 24 per cent in Southern zone; 12.1 per cent in Western zone and 6.19 per cent in Cauvery delta zone. Considering the annual rainfall and potential evapotranspiration the dryland agriculture in different agroclimatic subzone fall under different climate types: predominantly semi arid environment (ARF/PET = < 0.5) in North western zone, Western zone, Cauvery Delta zone and Southern zone while, it is sub humid climate (ARF/PET = 0.8) for North eastern zone and high rainfall zone and humid climate (ARF/PET = 1.0) for High altitude and Hillyzone.

Dryland areas of Tamil Nadu are vulnerable for intense radiation, high temperatures and highly variable rainfall. Droughts and floods, the extreme physical sisters are of periodical visitors. Deficit rainfall years may be followed by similar years or years with excess rainfall years in uncertain pattern.

Hence dry farming is a risky enterprise in Tamil Nadu. Unless massive efforts are taken to consolidate the research findings generated so far and also to enlist constraints facing transfer of effective technologies, the dry farming in Tamil Nadu would not be a sustainable enterprise in the coming years.

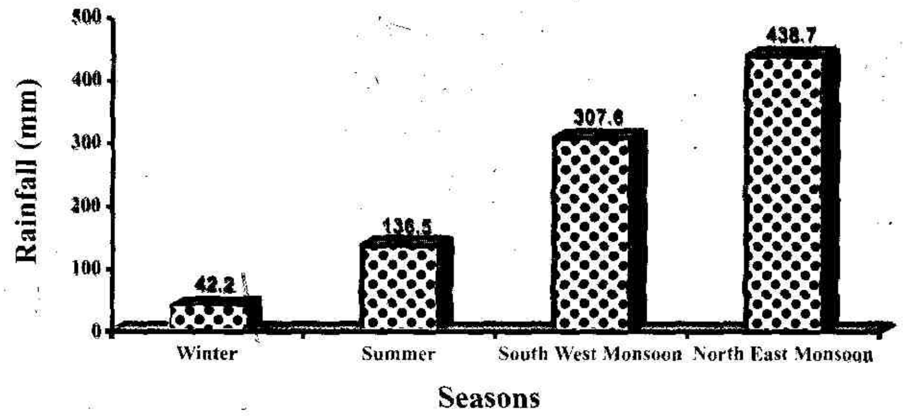
2. Resource Inventory in Tamil Nadu Dryland Agriculture

2.1 Physical Resources

2.1.1. Rainfall

Among two predominant weather systems, SWM rainfall contributes more than 70 per cent of total annual rainfall in most parts of India with the exception of Tamil Nadu wherein NEM dictates agricultural production. The western ghats acting as a barrier deprive this State from the full blast of SWM winds. NEM rains are brought by the troughs of low pressure, establishing in South Bay of Bengal between October and December. The average rainfall of Tamil Nadu is 925 mm and its distribution in different seasons is 308 mm in SWM season, 439 mm in NEM season 42 mm in cold weather period and 137 mm in summer season (Fig.1).

Fig.1. Rainfall distribution pattern of Tamil Nadu (Average of 70 years observation)



During winter the rainfall amount ranges from 19 mm (Dharmapuri) to 71.6 mm (Thanjavur) across different districts of Tamil Nadu, while it is 59.9 mm (Chennai) to 321.5 mm (Kanyakumari) during summer. During SWM the rainfall amount ranged from 59.9 mm (Tuticorin) to 1022 mm (The Nilgiris). A review of normal rainfall of NEM reveals that in all the districts it is more than 400 mm except Vellore (379 mm), Salem (313 mm), Dharmapuri (312 mm), Coimbatore (328 mm), Erode (308 mm), Trichirapalli (398 mm), Pudukottai (399 mm), Madurai (387 mm) and Sivaganga (394 mm). When comparing the normal rainfall between SWM and NEM over years, Vellore, Thiruvannamalai, Salem, Dharmapuri, Pudukottai, Kanyakumari districts receive equal amount of rainfall both from SWM and NEM (Fig.2a-2d). In respect of Nilgiris, the predominance of SWM rainfall (1022 mm) has been noted as compared to NEM normal rainfall (494 mm).

Hence the livelihood of farmers in Tamil Nadu mainly depends on the contribution of NEM rainfall rather than rainfall from SWM.

Fig. 2a. Winter rainfall in different districts of Tamil Nadu

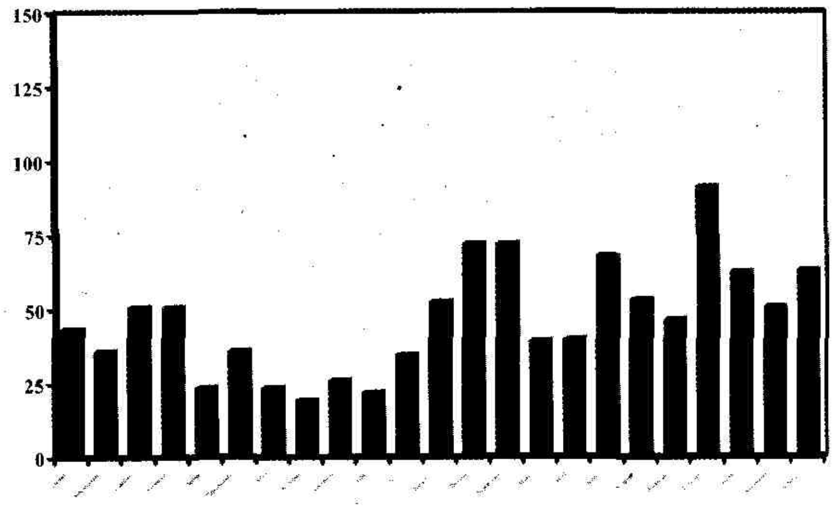


Fig. 2b. Summer rainfall in different districts of Tamil Nadu

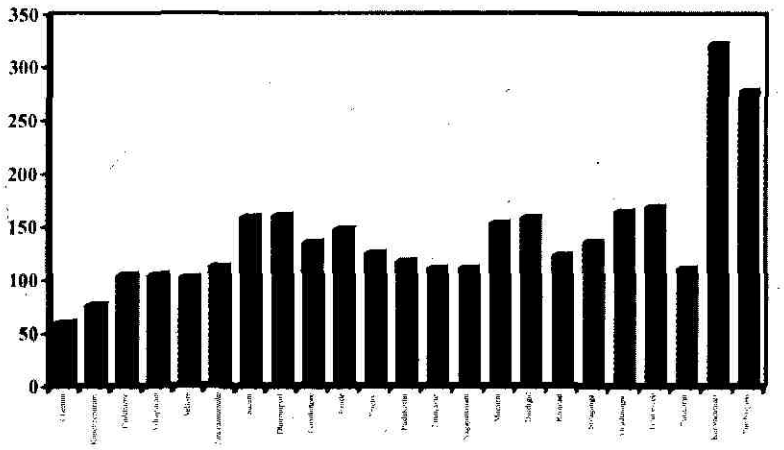


Fig. 2c. South-West monsoon rainfall in different districts of Tamil Nadu

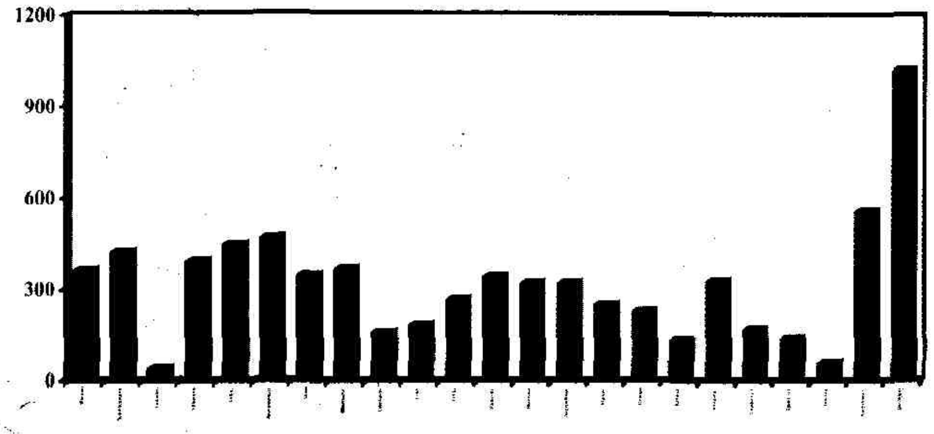
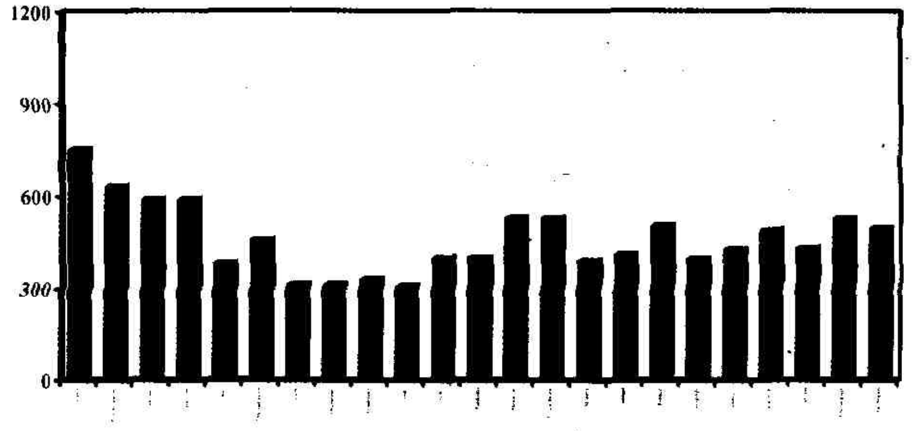


Fig. 2d. North-East monsoon rainfall in different districts of Tamil Nadu



Of the total annual precipitation of 925 mm in Tamil Nadu, the State receives 439 mm rainfall from NEM season, accounting for 48 per cent. In other words an amount of 3.5 million ha m of water is received over 6.98 million hectares of cultivable land from NEM. The whole State receives 6.214 m ha m of water for the geographical area of 13 million hectares against the rainfall water resource of 400 million ha m for India.

An analysis of rainfall pattern during five NEM years in Tamil Nadu from 1993 to 1997 revealed that the State has recorded more than normal in three years (1993, 1996 and 1997) normal in one year (1994) and deficit in another year (1995). This indicates that in 60 per cent of the years of NEM, there would be flood havoc due to excessive rain and on the contrary, in 20 per cent of the years, Tamil Nadu has to face drought.

The inference from the comparison of NEM rainfall in different districts of Tamil Nadu (1970-1994) indicated that more than the average rainfall for the State was recorded in Chennai, Chengleput, South Arcot, Thanjavur, Ramanathapuram, Tirunelveli, Kanyakumari and The Nilgiris. The remaining districts recorded less than the State NEM average rainfall of 478 mm and among them Dharmapuri, Erode and Salem districts accounted for the least rainfall. Since these three districts receive lesser rainfall than that of State average, these areas always fall under drought during NEM season.

Rainfall variability could be well studied through co-efficient of variation (CV). For any season with reference to rainfall it should be well below 50 per cent. The CV for NEM rainfall for Tamil Nadu is 30.6 per cent. When CV of rainfall (NEM) of different districts are compared with this State CV, the result indicated that, the CV is lesser than State average for Chennai and Chengleput districts, while it was between 30.6 and 40 per cent for South Arcot, Vellore, Salem, Dharmapuri, Trichirapalli, Thanjavur, Pudukottai, Madurai, Ramanathapuram, Tirunelveli, Kanyakumari and The Nilgiris. The districts Coimbatore and Erode recorded more than 40 per cent indicating relatively greater variability as compared to other districts.

A study on the onset of NEM rainfall in Tamil Nadu, for the years from 1971 to 1992 indicated that the

normal onset was on Julian day 295 (October 22nd) with a standard deviation of 7.45. The analysis also indicated that out of 22 years of study period, the normal onset occurred in 68 per cent of years, while it was 14 and 18 per cent respectively for late and early onsets.

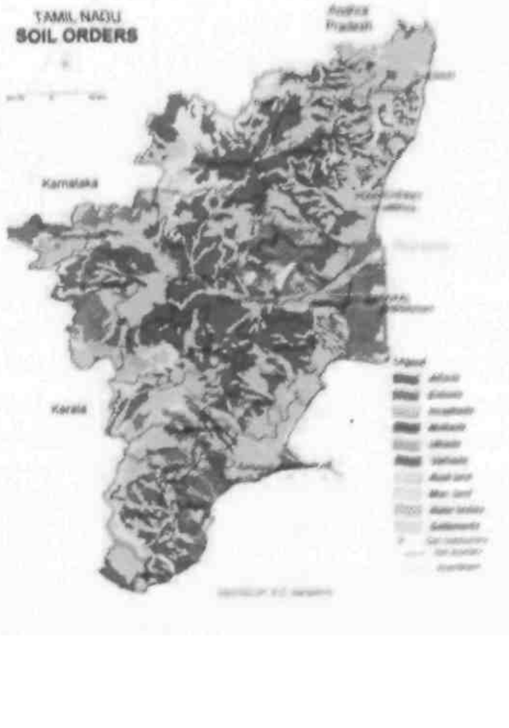
Among the districts, the peak NEM rainfall occurred in November at Chennai, Chengleput, South Arcot, Thanjavur, Nagapattinam, Tirunelveli, Tutirorin and Ramanathapuram districts (Coastal districts) and the quantity of rainfall during November varied from 184.7 to 346.7 mm. In the other districts (Central and western parts), the peak occurs during October and it ranged between 165.9 and 251.6 mm which was lesser than that of coastal districts indicating temporal and spatial variation of NEM rainfall in Tamil Nadu. All the cited information indicated the undependability of NEM even though it is the only monsoon that supports dryland agriculture in Tamil Nadu.

Based on the moisture index study of Thornthwaite and Mather(1995), climatic types of different districts of Tamil Nadu during NEM were critically analysed. The result indicated that the Nilgiris comes under per humid climate; while Chengleput, Vellore, Cuddalore, Thanjavur, Tirunelveli and Kanyakumari come under humid climate; Trichirapalli, Pudukottai, Madurai and Ramanathapuram come under moist sub humid. Coimbatore, Dharmapuri and Salem come under dry sub humid climate. These data support that moisture is not limiting factor for crop production during NEM in all the districts of Tamil Nadu excepts Salem, Dharmapuri and Coimbatore districts.

2.1.2 Soils

The predominant soils of Tamil Nadu are loam, laterite, black, alluvial and saline soils. Both red and black soils occur in the drylands and some areas coastal alluvium occurs. The soil map of Tamil Nadu is presented in Fig. 3.

Fig. 3. Predominant soil orders and their distribution in Tamil Nadu

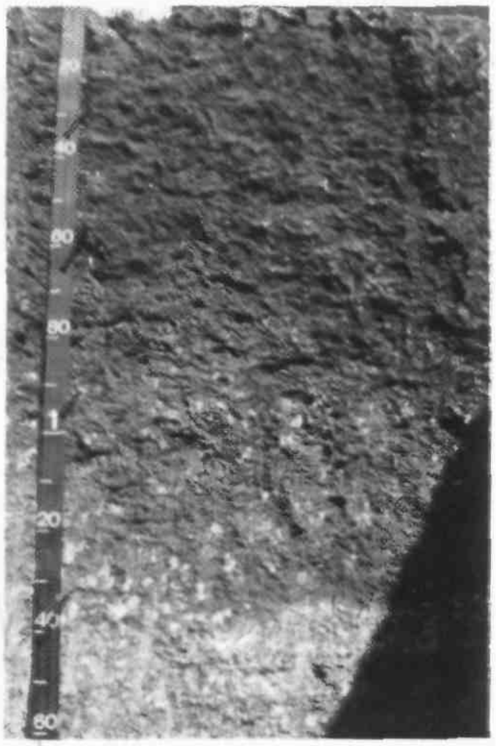


2.1.2.1. Black Soils

Deep black soils are extensively seen in parts of Tirunelvelli,Tuticorin, Viridunagar, Ramandhapuram, Trichirapalli, Salem, Dharmapuri, Coimbatore, Cuddalore and Vellor districts.

The black soils possess greater production potential, but are poor in organic matter and structure and so suffer from higher expansion and shrinkage properties. The profile discription of the black soil is presented in Fig. 4.. Low infiltration rate and consequently more runoff are also constraints in this area. Rainy season in this environment lasts for 2 to 3 months.

Fig. 4. A typical black soil profile



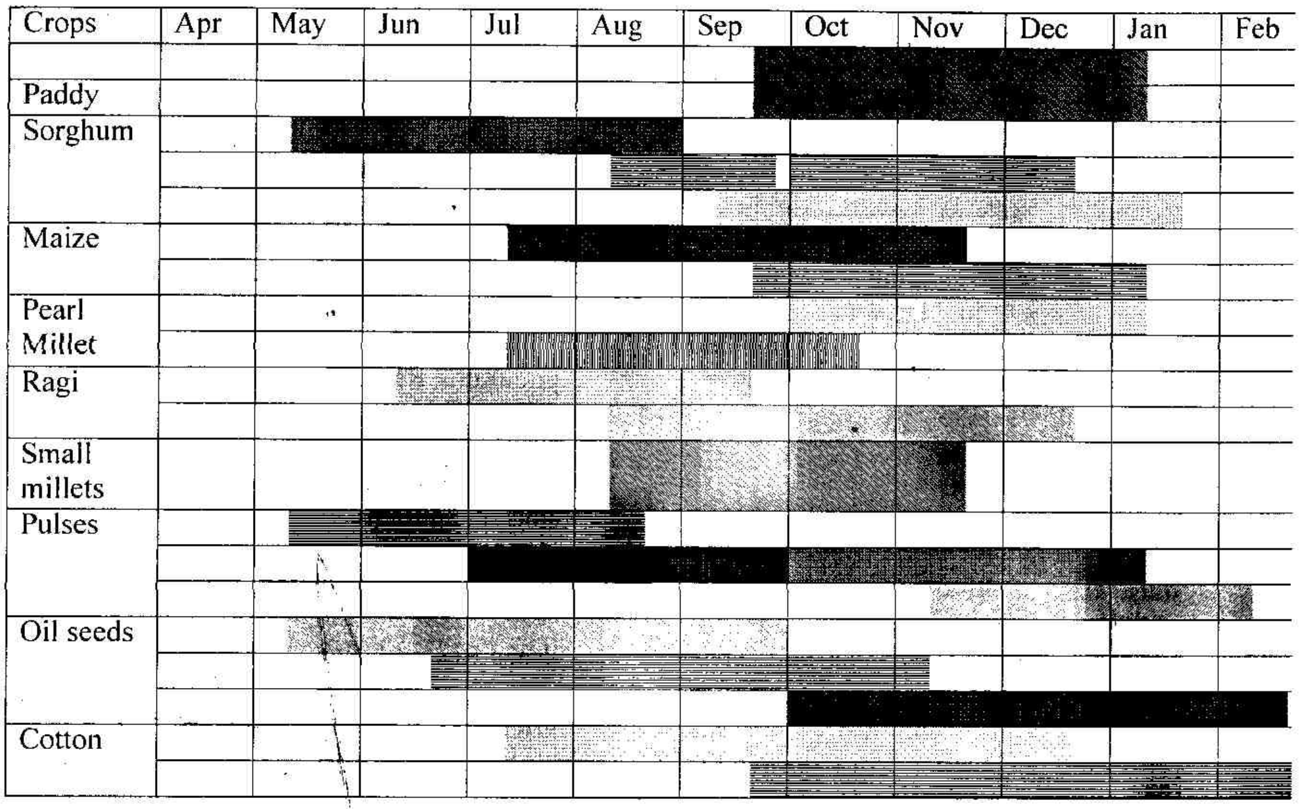
2.1.2.2. Red Soils

Red soils are extensively found in parts of Ramanathapuram, Pudukottai, Madurai, Coimbatore, Salem, Trichirapalli, Chengleput, Vellore, Cuddalore and Villupuram districts. The topography in general is rolling and undulating with moderate slopes as in Pollachi area. These soils are shallow to medium in depth, well drained, light to medium in texture and low in moisture retention capacity. These soils are poor in N and P. Deficiency of calcium and sulphur may occur.

2.2 . Crops, Cropping Systems and Productivity

The cropping pattern commonly observed in dryland areas of Tamil Nadu are presented in Fig. 5.

Fig. 5. Cropping Pattern in Dryland Regions of Tamil Nadu



2.2.1. Southern Zone

The zone comprises Virudhunagar, Sivagangai, Ramanathapuram, Tirunelveli, Tuticorin, parts of Madurai, Theni and Dindigul districts. Major areas of the zone is occupied by red soil, deep red loam soil, red sandy soil and black soil. In the black soil areas, sorghum, cumbu, cotton pulses like blackgram, greengram, redgram, sunflower, groundnut, coriander, senna etc., are being grown during NEM period. The average productivity of sorghum is 3228 kg /ha, while it is 2566 kg/ha for cumbu, 895 kg/ha kapas for cotton, 773 kg/ha for blackgram, 825 kg/ha for greengram, 723 kg/ha for cowpea, 928 kg/ha for redgram, 1668 kg/ha for groundnut, 975 kg/ha for sunflower and 450 kg/ha for coriander. A comparision of average productivity and the attainable productivity in this zone is presented in **Fig.8**. Senna's productivity is around 10 t/ha (leaf) with a pod yield of 175 kg/ha. Normally single crop is being raised during NEM in this zone.

2.2.2. North Western Zone

In black soils, the major crops are sorghum, cumbu, sunflower, bengalgram and coriander while in red soils, groundnut, gingelly, ragi, sorghum, samai, varagu, redgram, blackgram, greengram, cowpea, lablab are being grown. Two rainfed crops are being sown, one during SWM period and another one during NEM period. The important cropping system is ragi-horsegram, groundnut-horsegram and gingelly-horsegram. The productivity of the dryland crops are below the state average due to poor soil and uncertain rainfall events.

2.2.3. North Eastern Zone

The soils are mainly of loam to sandy loam, red soil with medium depth and to a little extent with black soils. Two well marked dryland seasons could be observed. During South west monsoon, groundnut, sesame, cumbu are being sown in red soils. Similarly, during NEM season groundnut, sesame are being grown. In black soils, varagu, coriander, sorghum and redgram are being sown during NEM season only.

2.2.4. Western Zone

The soils of this zone consists mainly of thin red soils and black soils. The red soils are shallow originating from ancient metamorphic rocks. Red soils occur side by side with black soil. Deep loamy red soils occur in some areas of southern Coimbatore district. The probability of having crops during the SWM period is in four years out of 10 years. NEM forms the major cropping zone of this zone. Sorghum, maize, cotton, groundnut, pulses including redgram are the main dryland crops during NEM period. The productivity of maize is around 3000 kg/ha, while it 2050 kg/ha for sorghum and 700 kg/ha for cotton (Kapas). Since groundnut is grown in coarse texture soil its productivity is around 700 kg/ha. Sorghum + Pulses, Groundnut + Pulses are important dryland cropping system.

2.2.5. Cauvery Delta Zone

Sorghum, cumbu, gingelly, pulses are being raised under dryland situation. In South west parts of this zone, during SWM period, dryland crops are being grown. Crops productivity is similar to the productivity of dryland crops of North western zone.

3. Dryland Research Generating Centers

Tamil Nadu Agricultural University operates research programme for the improvement of drylands' productivity through its research stations. The main research stations are:

Regional Research Station,
Kovilangulam, Aruppukottai

Agricultural Research Station,
Kovilpatti

Agricultural Research Station,
Ramanathapuram

Regional Research Station, Paiyur

Oilseed Research Station, Tindivanam

Agricultural College and Research Institute, Coimbatore

Agricultural Research Station,
Paramakudi

4. Sustainable Technologies Developed

Land use system, nutrient management soil and water conservation aspects are the important research areas to be tackled under research in order to achieve sustainability. Other research areas are complimentary to the above.

Important technologies generated are listed hereunder:

4.1. Black soils

4.1.1. Land Configuration (Conservation Agronomy) (for Assured Rainfall Region)

4.1.1.1

In a study at regional research station Aruppukottai on soil and surface runoff conservation, contour cultivation along with vetiver reduced both surface runoff and soil loss. (Table 1)

Table 1. Effect of vegetative hedges on soil loss and surface runoff in rainfed vertisols

Season	Total rainfall (mm)	Surface runoff (mm)			Soil loss (t ha^{-1})		
		T_1	T_2	T_3	T_1	T_2	T_3
1987-88	639	51.1	13.3	26.8	8.3	1.7	2.5
1988-89	1267	293.2	226.3	167.0	24.3	15.7	6.8
1989-90	577	69.1	53.6	30.4	1.9	1.3	0.6
Total	2482	413.6	293.2	223.2	34.5	18.7	9.9
Mean	827.3	133.9	97.7	74.4	11.4	6.2	3.3

T_1 – Cultivation across the slope T_2 – Contour cultivation along Leucaena T_3 – Contour cultivation along Vetiver

4.1.1.2

At Kovilpatti the result on moisture conservation practices indicated the superiority of compartmental bunding and tied interrows (Table 2 and 3).

Table 2. Effect of land treatments on sorghum grain yield and soil moisture

Treatments	Grain yield (kg/ha)	Mean soil moisture (%) at 0-15 cm depth
Flat bed system	1740	15.6
Compartmental bunding (7.2 x 3.6 m)	2464	18.2
Broad Bed and furrows system (150 cm width)	2445	16.8
Ridges and furrows (45 x 15 cm)	2378	17.5
CD	584	-

Table 3. Effect of soil moisture conservation on yield of cotton MCU.6

Treatments	Yield (q/ha)
Tied inter rows	4.34
Small watersheds	3.96
Compartmental bunding	4.20
Control	3.60

4.1.1.3

Among the vegetative barriers studied at ARS. Kovilpatti the result indicated the superior performance of vetiver grass (Table 4 and 5).

Table 4. Yield of Bajra and vegetative barrier of kuz kuz

Treatments	Grain Yield (kg/ha)	Straw yield (kg/ha)
Vegetative barrier at 25 m interval (1.5 m wide)	2208	4636
Furrows formed across the slope	2062	4302
Farmer's practice (control)	1632	3427

Table 5. Vegetative barriers on the sorghum yield

Treatments	Grain Yield (q/ha)	Straw yield (q/ha)
Vettiver grass – vegetative barrier	13.1	27.9
Lemon grass vegetative barrier	13.4	28.6
Compartmental bunding	12.4	26.5
Broad bed furrows	12.5	20.5
Strip cropping	12.1	25.9
Farmers practice	11.7	24.8

4.1.2. Crops and cropping system

4.1.2.1

At ARS, Kovilpatti, the study made on different crops indicated that sorghum, ragi nd cotton recorded the highest moisture use efficiency (Table 6).

Table 6. Moisture use efficiency of crops

Crops	Moisture use efficiency kg/ha/mm
Sorghum	4.40
Bajra	2.40
Ragi	6.50
Cotton	4.10
Sunflower	1.50
Blackgram	0.61
Redgram	0.12
Greengram	0.84
Cowpea	0.53
Clusterbeans	3.60

4.1.2.2

At Kovilpatti cotton + Blackgram intercropping system, cotton + clusterbean intercropping system, sorghum + cowpea/blackgram, maize +greengram intercropping system were the most profitable systems than any other combinations (Table 7,8 and 9).

Table 7. Effect of cotton with inter crops on yield and monetary returns

Cotton + intercrop	Uniform row	Paired row	Pure crop
Cotton + Blackgram	2584	2638	1364
Cotton + Greengram	2523	2072	653
Cotton + Cowpea (long duration)	2513	2528	1203
Cotton + Cowpea (short duration)	2493	2094	938
Cotton + Lablab	582	785	126
Cotton + Sunflower	2591	1856	1336
Cotton + Safflower	1200	1108	305
Cotton + Sesaum	2414	1935	1557
Cotton + Bajra	657	839	405
Cotton + Sorghum (grain)	933	1318	800
Cotton + Sorghum (Straw)			
Cotton + Thenai	2301	2157	500
Cotton + Coriander (Grain)	3016	2607	920
Cotton + Coriander (leaf)			
Cotton pure	1614	1619	
Mean	1956	1812	

Table 8. Results of sorghum based cropping systems

Year	Best intercrop combination in sorghum	Return (Rs./ha)	Land equivalent ratio
1978-79	Sorghum CSH 6 + Lablab CO6	-	-
1979-80	Sorghum + Cowpea	1058	-
1980-81	Sorghum + Cowpea follwed by	3095	1.15
	Sorghum + Blackgram	2268	1.12
1981-82	Sorghum (CSH 6) + Blackgram	2350	1.10
	Followed by Sorghum + Cowpea	2227	1.08
1982-83	Sorghum + Greengram followed by	1723	1.26
	Sorghum + Blackgram and	1670	1.35
	Sorghum + Cowpea	1342	1.14

Table 9. Maize intercropping system for rainfed vertisols

Treatment	Base crop		Inter crop		Land equivalent ratio
	1984-85	1985-86	1984-85	1985-86	
Maize + Greengram	1385	961	353	43	1.08
Maize + Blackgram	1690	773	201	13	0.85
Maize + Lablab	1191	583	215	34	0.73
Sole Maize	2045	877	-	11	0.92
CD	525	164	NS	12	

4.1.3. Times of sowing

4.1.3.1

Trials conducted at RRS, Aruppukottai has revealed that premonsoon sowing of sorghum and cotton two weeks prior to onset of monsoon was optimum. For redgram, sowing done during first fortnight of September recorded higher grain yield (Table 10 and 11).

Table 10. Effect of pre-monsoon sowing in rainfed cotton and sorghum

Treatments	Crop yield (kg ha^{-1})	
	Cotton	Sorghum
1. Pre-monsoon sowing – two weeks ahead	419	2033
2. Monsoon sowing	210	1848
3. Sowing two weeks after monsoon rains	120	329

Table 11. Effect of pre-monsoon sowing on redgram yield

Treatments	Grain yield (kg ha^{-1})
1. Sowing during September 1st fortnight	812
2. Sowing during September second fortnight	304
3. Sowing during October 1st fortnight	158
4. Sowing during Octoberr second fortnight	78
CD	34

4.1.3.2

Experiments conducted at RRS, Aruppukottai revealed that pearl millet was the suitable crop for sowing during the onset of NEM (Oct.15). When the rainfall delayed for another 15 to 30 days, pearl millet and sunflower were the best choice for sowing up to November 15th. Under late monsoon rainfall situation, senna was the best (Table 12).

Table 12. Grain yield of different crops under different sowing time

S.No.	Treatment crops	Grain yield (kg ha^{-1})		
		I Sowing	II Sowing	III Sowing
1.	Cumbu	1483	1303	658
2.	Greengram	213	105	61
3.	Sunflower	548	736	491
4.	Gingelly	301	326	211
5.	Coriander	253	350	163
6.	Bengalgram	208	223	145
7.	Horsegram	477	520	423
8.	Senna leaf	2597	2787	2869
	Seed	47	53	56
9.	Coriander +	175	214	106
	Bengalgram	71	82	44
10.	Gingelly +	191	196	109
	Senna leaf	1140	1162	1205
	Seed	15	18	18

4.1.3.4

In respect of Kovilpatti, with the onset of normal monsoon rain, sowing either cotton and sorghum was recommended. If rain was delayed, bajra would be the best choice and if rain was delayed further sowing of sunflower was recommended under contingency situation.

4.1.4. Nutrient Management

Black soil in general is low in available N, medium in available P and moderately high in K. Calcium induced iron deficiency and zinc deficiency are very common. The presence of excess calcium and sodium results in alkaline range and limits availability of boron and potassium. The soil is less in Organic Carbon. Under this situation, the results of the studies attempted are listed hereunder.

4.1.4.1

At Kovilpatti, study was made to find out the nutrient efficiency of different crops (Table 13). Nitrogen efficiency was higher for Ragi and lower for cowpea. P efficiency was higher with cluster been and lower for cowpea.

Table 13. Optimum dose and nutrient efficiency of fertilizer

Crops	Optimum dose Kg/ha		Nutrient efficiency	
	N	P	Yield Kg N	Yield Kg P
1. Sorghum	40	20	52.5	24.5
2. Bajra	40	20	29.1	13.9
3. Ragi	40	20	79.0	34.4
4. Cotton	40	20	30.0	14.2
5. Sunflower	20	40	35.2	16.3
6. Blackgram	20	40	149	6.7
7. Redgram	20	40	29.2	12.9
8. Greengram	20	40	20.6	9.7
9. Cowpea	20	40	12.8	6.1
10. Clusterbean (Green pods)	20	40	86.1	40.1

4.1.4.2

In a sorghum based inter cropping system application of recommended NPK at 40:20:0 NPK kg/ha + addition of farm waste either of cumbu straw a tree lopping at 5 t ha^{-1} recorded higher net income in sorghum based intercropping system (Table 14).

Table 14. Effect of composted farm waste on sorghum yield

	Treatment	Sorghum grain yield (kg ha^{-1})	Net income (Rs.)	B:C ratio
1.	Control	844	488	1.13
2.	40:20:0 kg NPK ha^{-1}	1864	4439	2.02
3.	40:20:0 kg NPK ha^{-1} + Composted cumbu straw	2149	5452	2.14
4.	40:20:0 kg NPK ha^{-1} + Composted sorghum straw	2092	5162	2.08
5.	40:20:0 kg NPK ha^{-1} + Composted cotton straw	1989	4685	1.98
6.	40:20:0 kg NPK ha^{-1} + Composted coirpith	2092	5162	2.08
7.	40:20:0 kg NPK ha^{-1} + Composted sugarcane trash	2038	4877	2.03
8.	40:20:0 kg NPK ha^{-1} + Composted tree loopings	2177	5565	2.17
9.	40:20:0 kg NPK ha^{-1} as EFYM	2014	5059	2.12
10.	40:20:0 kg NPK ha^{-1} + Composted mushroom spent	1970	4566	1.96
11.	STL recommendation @ 80:30:6555 kg NPK ha^{-1}	2300	5377	1.98
	SEd	165	698	0.14
	CD	368	1556	0.31

4.1.4.3

In another experiment studied for cotton + blackgram intercropping systems, higher gross income was recorded with the application of 20:40:0 kg NPK + application of recommended dose of biofertilisers (Table 15).

Table 15. Effect of organic, inorganic and bio-fertilizer on yield of cotton and blackgram

Treatments	Seed cotton yield (kg ha^{-1})	Blackgram yield (kg ha^{-1})	Gross income (Rs.)	B:C ratio
T_1 – Compost @ 12.5 t ha^{-1}	801	169	9320	3.10
T_2 – 20:40:0 kg NPK ha^{-1}	1079	177	12022	4.00
T_3 – 40:20:0 kg NPK ha^{-1}	889	184	9900	3.30
T_4 – Compost @ 12.5 t ha^{-1} + Azospirillum @ 2.0 kg ha^{-1}	858	182	10111	3.37
T_5 – 20:40:0 kg NPK ha^{-1} + Azospirillum @ 2.0 kg ha^{-1}	924	164	10145	3.38
T_6 – 40:20:0 kg NPK ha^{-1} + Azospirillum @ 2.0 kg ha^{-1}	736	161	8247	2.74
T_7 – Compost @ 12.5 t ha^{-1} + Azatobacter @ 2.0 kg ha^{-1}	775	160	8637	2.87
T_8 – 20:40:0 kg NPK ha^{-1} + Azatobacter @ 2.0 kg ha^{-1}	817	173	9122	3.04
T_9 - 40:20:0 kg NPK ha^{-1} + Azatobacter @ 2.0 kg ha^{-1}	1049	185	12074	4.02
SEd	66	32	1960	-
CD	144	NS	NS	-

4.1.5. Alternate Land Use System

4.1.5.1

This system offers potential resource utilisation, when ever annual crops management is unsustainable. At RRS, Arruppukottai higher fodder yield was obtained when fodder sorghum was raised along with neem trees under agri-silvicultural system (Table 16).

Table 16. Fodder production of annual forages under different forage tree crops

Annual forage	Tree fodder			Mean
	Neem	Acacia	Sesbania	
Fodder cholam	349	257	238	281
Fodder maize	232	211	218	220
Fodder cumbu	194	177	154	175
Deenanath	131	115	114	120
Fodder cowpea	206	176	173	185
Fodder greengram	207	151	145	167
Mean	220	181	173	

4.1.5.2

Similarly under agri horticultural system raising either fodder cowpea or Dinanath or fodder sorghum either in between ber or sapota was found profitable (Table 17).

Table 17. Yield and economics of different horti-pastoral systems

Treatments	Green fodder yield (kg ha^{-1})	Fruit yield (kg ha^{-1})	Total gross income (Rs.)	B:C ratio
Horticultural components				
Mango	15.3	810	9572	1.11
Sapota	14.6	2126	18670	1.96
Ber	14.2	2897	21032	1.75
CD	6.2	1099	6847	0.07
Intercrops				
Fodder cholam	22.4	1627	16165	1.60
Fodder maize	18.4	1757	15947	1.57
Fodder cumbu	13.0	1893	1554	1.51
Fodder cowpea	9.3	2356	18230	1.76
Deenanath	10.4	2088	16227	1.60
CD	2.7	324	2454	0.24

4.1.5.3

In respect of Alley cropping system, the result from RRS, Aruppukottai revealed that subabul and *Desmanthus* forage alleys produced higher forage yield (Table 18)

Table 18. Yield of annual crops and forage crops in alley cropping system

Forage alley	Forage yield (kg ha^{-1})	Annual crop	Grain yield of annual crops (kg ha^{-1}) 1989-90	1990-91	1991-92	Gross income (Rs.)	Net income (Rs.)	B:C ratio
Desmanthus	3262	Sorghum	549	1421	1688	6640	5020	4.10
		Sun flower	740	183	568	4912	3282	3.01
		Maize	795	551	842	4805	2690	2.86
Perennial Pigeon pea	3009	Sorghum	588	1037	1600	6170	4544	3.69
		Sun flower	735	137	484	4210	2541	2.43
		Maize	604	431	816	3852	2188	2.22
Subabul	1840	Sorghum	535	1169	1496	6060	4458	3.78
		Sun flower	707	230	516	4661	3016	2.83
		Maize	585	649	768	4093	2473	2.52

4.1.5.4

At ARS. Kovilpatti wider alley of subabul and mulching with subabul leaves had increased the yield of cotton, blackgram and sunflower (Table 19).

Table 19. Influence of Alley cropping on annual crops (1984-85)

Treatments	Blackgram grain yield (kg/ha)	Sunflower grain yield (kg/ha)	Cotton kapas (kg/ha)
1. Sole crops	540	566	1465
2. Subabul planted at 3 m spacing (annual crop Without mulching of Subabul leaves)	498	520	1018
3. 3 m spacing with mulching	526	542	1180
4. 6 m spacing without mulching	426	547	1302
5. 6 m spacing with mulching	602	585	1544

4.1.6 Dryland horticulture :

The experimental results from RRS. Aruppukottai revealed the followings.

- Kaithalai in Ber ; ASI in custard apple were highly remunerable.
- Insitu budding for ber
- Pruning during last week of February for enhancing ber yield.
- Five percent slope towards trunk for moisture conservation in fruit crops.
- The optimum spacing for Banarasi Ber was 8 x 3m, while it was 8 x 4m for Kaithali Ber.
- Dipping of the ber fruit for 10 minutes in 2% sodium chloride or carbendazim 0.1% or 3% Kcl before storage reduced the post harvest rotting of ber fruits.
- Ber, custard apple, Amla, Pomegranate, sapota, West Indian cherries, Tamarind, neem were suitable for dryland horticulture.

4.1.7.Component Technologies

4.1.7.1 Seed Hardening

Based on the experiments conducted at RRS, Aruppukottai, seed hardening found to be a drought insulating technology (Table 20).

Table 20. Effect of seed hardening

Crop	Chemical	Soaking duration (h)	Seed rate (kg)	Soaking solution per kg of seed (ml)
Cholam	2% KH_2PO_4	10	15	350
Cumbu	2% KCl	16	5	350
Sunflower	2% KCl	12	15	650
Cotton	2% KCl	8	15	650
Pulses	100 ppm $ZnSO_4$	4	20	400

4.1.7.2. Weed Management

Pre-emergence application of butachlor at 1.0 kg ai ha^{-1} did control weeds effectively in cotton + black gram inter cropping system. Similarly pre-emergence application of benthiocarb at 1.5 kg ai/ha + one hand weeding on 40 DAS, controlled weeds effectively. Application of 2,4-D sodium salt in the morinda stem near the ground level after removing the bark for one inch height controlled the growth of morinda.

4.1.7.3

In another trial pre-emergence application of Isoproturon at 0.6 kg ha^{-1} + one hand weeding on 35 DAS found to control weeds effectively (Table 21).

4.1.8.Integrated Farming System (IFS) :

4.1.8.1

Trials conducted over years at RRS, Aruppukottai indicated the sustain ability of IFS than annual cropping. The IFS had agriculture and goat components. Under agriculture, annual crops (cotton, sorghum, pulses) were sown in 2.50 acre, forage crops (cenchus + Desmanthus) in 0.50 acre and fruit trees (Ber, sapota, Anona) in 1.00 acre. The animal component consisted of 5+1 Tellicherry goat. (Table 22).

4.1.8.2

At Kovilpatti maintaining two mulch cows with one hectare of land for agricultural (50% for cotton, sunflower and sorghum; remaining 50% for dry and green fodder) was economically possible, viable and sustainable (Table 23).

Table 21. Effect of different herbicides on yield and economics of sorghum based cowpea intercropping system in rainfed Vertisol

Treatments	Sorghum yield (kg ha^{-1})		Intercrop cowpea yield (kg ha^{-1})	Gross income (Rs.)	B:C Ratio
	Grain	Straw			
Weed control methods					
One hand weeding	1581	4912	45	4041	2.18
Two hand weedings	2079	6310	55	5383	2.63
Isoproturon spray @ 0.6kg ha^{-1}	2060	6277	42	5176	2.69
Isoproturon spray @ 0.6kg ha^{-1} + *one hand weeding on* 45 DAS	2289	7092	43	5755	2.71
Pendimethalin @ 0.75 kg ha^{-1}	324	921	53	971	0.47
Pendimethalin @ 0.75 kg ha^{-1} + *one hand weeding on 45* DAS	333	925	63	1029	0.46
Unweeded control	1046	3365	35	2756	1.78
SEd	49.3	87.1	3.4	127.8	
CD	101.4	179.1	7.4	242.1	
Crops					
Sorghum sole crop	1378	4244	-	3457	1.83
Sorghum + cowpea	1397	4271	-	3718	1.86
SEd	26.4	46.6	-	63	-
CD	NS	NS	-	129.4	-

e 22. Integrated Farming Systems in dryland vertisol

Year	Treatment	Net income (Rs.)	Additional income (Rs.)
1989-90	Control*	5526	-
	IFS	7889	2163
1990-91	Control	3840	-
	IFS	6390	2556
1991-92	Control	2346	-
	IFS	7552	5206
1992-93	Control	2542	-
	IFS	8792	6250
1993-94	Control	4996	-
	IFS	15897	10901
1994-95	Control	717	-
	IFS	16179	15462
Mean	Control	3328	-
	IFS	10417	7089

Table 23. Net income realized from the integrated Farming Systems

Year	Net income (Rs./ha)			Net income (Rs.ha)		
	Agrl.crop	Dairy unit	Total	Agrl.crop	Dairy unit	Total
1992-93	889	2319	3209	28	72	100
1993-94	-511	422	-79	-	-	-
1994-95	505	9542	10047	5	95	100
Mean	294	4094	4388	6.7	93.3	100

4.2. Red Soil

4.2.1. Land Configuration

4.2.1.1

The study conducted at RRS, Paiyur on cotton revealed that among tillage method, deep tillage had conserved higher mean soil moisture at all the depths and it led to higher cotton kapas yield. Similarly in corporation of 12.5 t ha^{-1} of composted coil pith enhanced soil moisture storage and cotton kapas yield (Table 24).

Table 24. Mean germination per cent, soil moisture content in per cent and mean kapas yield in kg ha^{-1} in cotton (LRA 5166)(1997-98)

Treatment		Mean germination *per cent*	Average soil moisture content in *per cent at depths of*			Pod yield (kg ha^{-1})
			15cm	*30cm*	*45cm*	
Shallow Tillage M1 -	S1	89.2	17.80	17.97	18.17	767
	S2	91.3	18.06	18.26	18.44	783
	S3	88.1	17.50	17.74	17.95	749
	S4	87.0	17.40	17.54	17.77	724
Deep Tillage M2 -	S1	90.5	18.08	18.25	18.42	830
	S2	92.1	18.33	18.54	18.68	852
	S3	89.3	18.88	18.02	18.22	809
	S4	88.6	17.70	17.83	18.03	789
No Tillage M3 -	S1	87.0	17.47	17.70	17.97	724
	S2	88.2	17.72	17.97	18.25	746
	S3	86.2	17.29	17.51	17.75	705
	S4	85.3	17.12	17.31	17.57	672

4.2.1.2

In a run off and soil loss studies there was minimum soil loss with lesser run off under pune groundnut, while these were higher under sole cotton (Table 25).

Table 25. Runoff, runoff in per cent of rainfall, soil loss and crop yield under different cropping systems in red soil of North Western Zone.(1997-98)

Treatments	Runoff producing rainfall mm	Total runoff mm	Runoff in per cent of rainfall	Soil loss t ha^{-1}	Main crop yield kg ha^{-1}
T1-Sorghum+lab-lab	568.8	113.5	19.95	2.95	362
T2-Groundnut + redgram	568.8	108.7	19.11	2.73	472
T3-Groundnut + castor	568.8	108.2	19.02	2.62	484
T4-Cotton + blackgram	568.8	116.4	20.46	3.05	682
T5-Sorghum-horsegram	568.8	112.7	19.81	2.92	347
T6-Sorghumpure crop	568.8	114.2	20.07	3.01	368
T7-Groundnut pure crop	568.8	106.8	18.77	2.60	496
T8-Cotton pure crop	568.8	118.1	20.76	3.27	670
T9-Fallow land (control)	568.8	148.3	26.08	5.72	

4.2.1.3

In the study on vegetative barrier at RRS, Paiyur, Vetiver planted across the slope recorded higher average soil moisture content throughout the crop period and this led to higher groundnut pod yield (Table 26).

4.2.1.4

In the micro catchment studies for mango, for dense planted mango orchard micro catchment of 25x5 m size with 1.5 percent slope conserved more soil moisture (Table 27).

Table 26. Mean germination per-centage, average soil moisture adn mean dry pod yield of groundnut (ALR 2)(1997-99)

Treatment	Mean germination per cent	Average soil moisture content in per cent at depths of			Pod yield (kg ha^{-1})
		15cm	30cm	45cm	
T1 -Khus grass as vegetative barrier	91.5	18.92	19.15	19.58	474
T2 -Cenchurs sp. vegetative barrier	89.5	18.19	18.43	18.71	426
T3 -Subabul vegetative barrier	89.0	18.35	18.59	18.91	437
T4 -Desmanthus sp vegetative barrier	88.5	18.69	18.91	19.34	472
T5 -Agave vegetative barrier	88.0	18.53	18.75	19.13	455
T6 -Palmarosa vegetative barrier	87.0	18.02	18.25	18.50	412
T7 -Flat bed (control)	86.0	17.83	18.07	18.30	377
SED	0.38	0.08	0.07	0.08	11.8
CD (5%)	0.85	0.174	0.162	0.179	35.4

Table 27. Mean soil moisture per cent and tree canopy measurements in microcatchments of different sizes in mango (Paiyur 1) in red soils.

Treatment (microcatchment)	Average soil moisture (%)	Tree canopy dia (cm)		Plant height (cm)
		East to West	North to South	
T_1 Size 25x6m with 1.5% slope	18.27	147	149	159
T_2 size 25x5m with 1.5% slope	18.52	152	154	162
T_3 size 25x4m with 1.5% slope	17.79	141	142	148
T_4 size 20x6m with 2.0% slope	17.96	142	144	152
T_5 size 20x5m with 2.0% slope	18.11	145	146	155
T_6 size 20x4m with 2.0% slope	17.64	139	140	145
T_7 flat bed (control)	17.45	136	138	142
SED	0.06	0.6	0.8	0.8
CD	0.17	2.5	2.7	2.8

4.2.2. Nutrient Management :

4.2.2.1

In an experiment conducted for a cropping system of sorghum - horsegram at RRS Paiyur it is observed that, eventhough the yield was higher for recommended fertiliser + FYM 10 t ha^{-1} benefit cost ratio was higher for the treatment 75 percent recommended fertilisers with bio fertilisers application (Table 28).

Table 28. Effect of organic, inorganic and biofertilisers under double cropping system in rainfed redsoils of North Western Zone of Tamil Nadu

Treatments	Sorghum grain yield (kg/ha)	Horsegram seed yield (kg/ha)	Sorghum-Horse gram	
			Net income (Rs./ha)	B:C ratio
T1- Recommended inorganic fertilisers (RIF) alone	1472	158	4567	2.4
T2- Farm Yard Manure (FYM) alone	1444	165	3934	2.1
T3- RIF + FYM	1586	145	4049	1.8
T4 – RIF + Biofertiliser	1577	161	5214	2.5
T5 – 75% RIF + Biofertilisers	1586	145	5314	2.6
T6 – Control	1016	115	2735	2.0
CD (P=0.05)	49	23	-	-

4.2.2.2

In a study on sources and levels of P on yield, nutrient uptake and economics under ragi-horsegram cropping system, highest grain and straw yields were obtained under 200% P 205 (40 kg/ha) as RP + Phosphobacteria (T8+VAM) application. In respect of the horsegram, the treatments with P solubilising agents (T9+VAM) showed their superiority over other treatments with reference to grain and haulms yield. It is concluded from the experiment that RP coupled with P solutilisers could be recommended in cereal- pulse cropping system under rainfed. (Table 29).

4.2.2.3

Samai, the minor millet responded well to Zn and Fe in the rainfed red loamy soil. Application of 6.25 kg of znso4 ha^{-1} combined with the 12.5 kg of $FeSO_4$ ha^{-1} enriched with FYM not only *increased the yield but also improved* crops uptake and soil fertility (Table 30).

Table 29. Sources and levels of P on economics of ragi – horse gram sequence

Treatment	Net return (Rs.)		B:C ratio
	Ragi	*Horse gram*	
T_1 – Control	728	120	1.29
T_2 – 100% (20 kg ha^{-1}) P_2O_5 as SSP	474	315	1.22
T_3 – 100% (20 kg ha^{-1}) P_2O_5 as RP	1003	435	1.41
T_4 - T_3 + Phosphobacteria	1240	527	1.50
T_5 – T_4 + VAM	924	448	1.36
T_6 – 200% (40 kg ha^{-1}) P_2O_5 as SSP	537	800	1.34
T_7 – 200% (40 kg ha^{-1}) P_2O_5 as RP	1270	653	1.51
T_8 – T_7 + Phosphobacteria	2692	895	1.93
T_9 - T_8 + VAM	3562	982	2.11

Table 30. Effect of Zn and Fe on yield and nutrient content in Samai

Treatments	Yield (kg/ha)	Nutrient content in grain	
		Zn (ppm)	*Fe (ppm)*
T_1 NPK control	1087	20.5	894.0
T_2 $ZnSO_4$ 25.0 kg ha^{-1}	1226	44.9	1700.0
T_3 Fe So_4 25 kg ha^{-1}	1254	34.5	1853.3
T_4 - T_2 + T_3	1233	43.6	1603.3
T_5 - $ZnSO_4$ 6.25 kg ha^{-1} Enriched with FYM	1273	30.6	1869.3
T_6 $FeSO_4$ 12.5 kg ha^{-1} Enriched with FYM	1297	23.0	1798.7
T_7 - T_5 + T_6	1395	28.1	1657.3
T_8 P (20 kg ha^{-1}) and $ZnSO_4$ 6.255 kg ha^{-1} enriched with FYM	1269	37.0	1630.0
T_9 $ZnSO_4$ 0.5% + $FESO_4$ 1.0% foliar spray	1198	44.9	1818.0
CD (p=0.05)	66.6	16.7	500.5

4.2.2.4

In another study for rainfed tomato application of 75 percent soil test based nitrogen application combined with composted coirpith application gave highest BC ratio and this was followed by the treatment 100% STB-N+CCP (Table 31).

Table 31. Effect of inorganic N, organics and bio fertiliser on fruit yield of tomato

STB-N	Fruit Yield (t/ha)				
	Control	Azos	CCP	FYM	Mean
1. 0	3.71	3.96	7.61	7.04	5.45
2. 50%	8.86	10.44	16.11	11.27	11.67
3. 75%	10.70	11.11	17.36	15.07	13.36
4. 100%	11.92	12.12	17.62	16.38	14.51
Mean	8.66	9.40	14.68	12.44	-

Source	Cd (p=0.05)
Nitrogen	1.28
Organics	1.28
Interaction	2.57

4.2.2.5

In an INM experiment for groundnut horsegram cropping system integration of 75 percent and 100% STB-N with 5t ha^{-1} of composted coirpith resulted in higher pod yield of groundnut and grain yield of horsegram (Table 32).

Table 32. Effect of INM on yield of groundnut and Horsegram sequence

Treatment	Groundnut pod yield (kg/ha)	Horsegram grain yield (kg/ha)
1. BF alone	1453	590
2. EFYM alone	1332	578
3. CCP alone	1450	586
4. 50% STB-N + BF	1402	512
5. 50% STB-N +EFYM	1410	595
6. 50% STB-N+CCP	1443	610
7. 75% STB-N + BF	1542	626
8. 75% STB-N +EFYM	1595	630
9. 75% STB-N+CCP	1677	638
10. 100% STB-N + BF	1685	628
11. 100% STB-N +EFYI	1650	639
12. 100% STB-N+CCP	1742	636
13. Control	1198	567
CD	227	38

4.2.3. Component Technologies

From the study conducted on the control of weeds in cowpea at RRS, Paiyur the result indicated the superiority of the treatment fluchloralin at 1.5 lha^{-1}, applied on 3 DAS with one hand weeding on 30 DAS. In respect of green gram, application of fluchloralin at 1 l ha^{-1} applied on 3 DAS + one hand weeding 30 DAS resulted in higher yield. (Table 33)

Table 33. Effect of various weed control treatments on seed yield and economics of rainfed cowpea and green gram (mean of two years)

Treatment details	Cowpea		Greengram	
	Seed yield (kg/ha)	Net return (Rs./ha)	Seed yield (kg/ha)	Net return (Rs./ha)
1. Fluchloralin 1.0 l/ha 0 DAS + HW	931	2542	811	3889
2. Fluchloralin 1.0 l/ha 3 DAS + HW	1107	3633	883	4526
3. Fluchloralin 1.0 l/ha 5 DAS + HW	907	2410	680	2772
4. Fluchloralin 1.5 l/ha 0 DAS + HW	920	2305	842	3964
5. Fluchloralin 1.5 l/ha 3 DAS + HW	1180	3893	798	3653
6. Fluchloralin 1.5 l/ha 5 DAS + HW	910	2234	631	2144
7. Hand weeding twice	1087	3310	914	4625
8. Un weeded check	337	-92	174	-523
CD	163	NA	121	NA

HW = Hand weeding on 30 DAS
NA = Not statistically analysed

5. Scopes for Integration of Different Research Disciplines

5.1. Quality Seeds and Availability

The comparison of seed quality between irrigated agriculture and dryland agriculture indicated that less importance is given by the farmers to seeds of dryland agriculture. In fact quality seed is most required for dryland agriculture since the environment is harsh and fragile and there is always risk of soil moisture. Resource poor nature of dryland farmers often limits the seed replacement rate and they use their own seeds. Hence inexpensive quality seed production exclusively for dryland has to be initiated by scientists from Department of Seed Science and Technology.

5.2.Soil Health

Normally dryland farmers do not go far inorganic source for fertilising their dryland crops. The only source is from farmyard mannure. Eventhough it improves soil health, it does not meet the crops immediate demand. In this context, many heat tolerant microbes have been developed as bio fertilisers. This has to be integrated in the soil nutrient chain. As per the research findings out of 80 Azospirillum cultures tested for dryland soils, 20 were tolerant to high soil temperature up to 50° c and these cultures possess high nitrogenace activity even at that high temperature level.

5.3. Mechanisation of Dry Farming

Dryland always faces problem from labourers at the time of sowing and other operations since the rainfall is the key factor. Urbanisation also invigorates labour demand further. In this context the only solution would be complete mechanisation of dryland agriculture in a phased manner. Tillage and land shaping implements, sowing implements, intercultural implements and harvesting equipments are already developed and field tested. For their spread, finance and extension sectors need strengthening. Under dryland soil and moisture conservation is a very

important activity. All land configuration practices require labour. In the absence of the labour, technology did not find a place in dryland agriculture. Suitable intervention from implements would not only improve the moisture conservation, but also reduces the cost, making the dryland agriculture sustainable.

5.4. Physiological Approaches

Moisture stress would be the rule in dryland agriculture rather than an exemption. Many physiological techniques could be exploited to keep the crops under normal even under severe moisture stress condition. Seed hardening, foliar application of chemicals, nutrients and growth harmones are necessary.

5.5. Watershed Approach

Developmental works executed in 15 microwatersheds of drought prone areas of Coimbatore district like bunding, percolation ponds, farm ponds, check dams, afforestation etc. provided substatntial quantum of ground water recharge (5-10 m), silt deposition behind the check dams and employement generation(10000-12000 mandays per watershed).

6. Research Gaps

Based on the research conducted so far the following research gaps have been identified.

- Since labour becomes a major constraint rigorous testing of agricultural implements from land preparation to post harvest is mostly required
- Intensive research on IFS on watershed basis
- Development of Decision Support Systems for dryland agriculture
- Identification of length of growing period for each taluk for dryland situation and fixing optimum times of sowing through water balance models
- Intensive OFR on system approach
- Intensive research on dryland horticulture
- Intensive research on INM for all dryland crops including micronutrients

7. Extension Gaps

- Weather forecasting system for each taluk of Tamil Nadu
- Lesser concentration by the extensionist on the dryland technology transfer
- Integration of dryland activities for each district

8. Policy issues

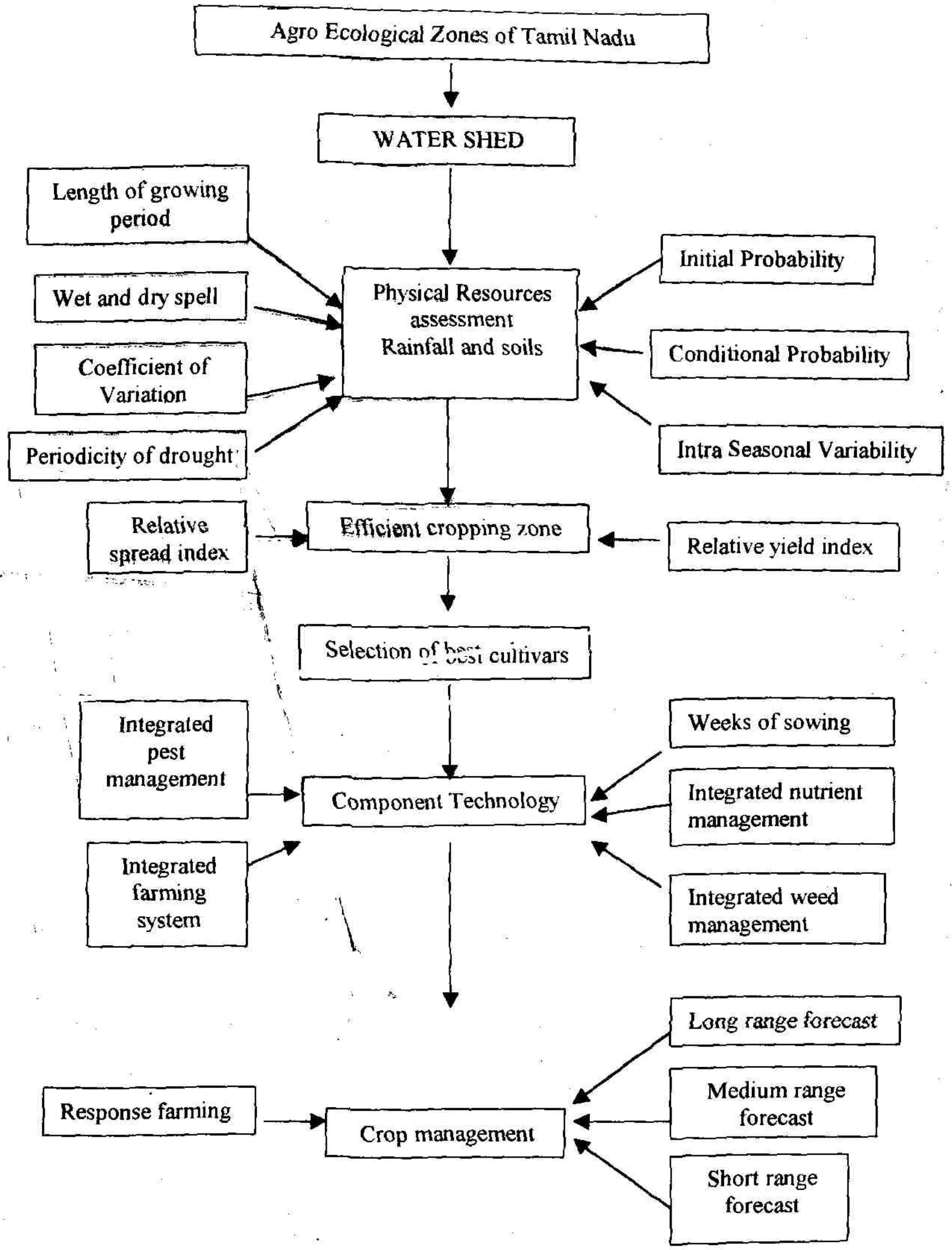
If rainfed green revolution is to be generated from drylands, efforts must be concentrated on the identification of watershed for each district of Tamil Nadu and comprehensive dryland approach should be adopted. In dryland domain, lack of economical resource coupled with non availability of crop seeds accounted for 40 percent of total dryland problems.

The following policy issues may be considered.

- Creation of watershed society for each watershed and making dryland farmers as members.
- Participatory decision making in the society for dryland management.
- Government should encourage the society in all possible ways including farmers training.
- Considering the food security, 60 percent of each dryland watershed may be grown with food crops and

- the balance 40 percent may be allotted for dryland horticulture.
- Government should offer support price for the produce obtained from dryland to motivate the farmers to involve dryland technologies.
- The technical model given in the flow chart for each watershed should be executed with due participation of agronomist, soil scientist and agricultural meteorologist.
- Red soil research should be strengthened further since majority of Tamil Nadu soil comes under red soils.

SUSTAINABLE APPROACH FOR DRYLANDS PRODUCTIVITY



Source: Department of Agricultural Meteorology, TNAU, Coimbatore - 3

PROCEEDINGS OF THE GROUP DISCUSSION ON DRYLAND GREEN REVOLUTION IN TAMIL NADU – THE PERSPECTIVES

The group meeting was conducted at the Freeman Hall of Department of Agronomy on 19.07.2000 under the Chairmanship of Dr.T.M.Thiyagarajan, Director (SCMS), TNAU. Thiru.Marimuthu, JDA (Sugarcane), Directorate of Agriculture, Chennai acted as Co-Chairman. Forty three scientists from TNAU and 10 State Department officials participated in the group discussion.

To start the discussion, one lead paper on "Dryland Green Revolution in Tamil Nadu - The perspectives" was presented by Dr.T.M.Thiyagarajan, Director (SCMS) by using visual aids covering the resource analysis of Tamil Nadu, technology developed so far for Vertisol and Alfisols, scope for further multidisciplinary research of TNAU, research gaps, extension gaps and policy issues.

The Joint Director of Agriculture from dryland districts, especially from the Southern district of Tamil Nadu, participated in the discussion.

Remarks of Extension Officials

- It is better to pick out moisture efficient and nutrient efficient dryland crops from the varieties released so far from TNAU (JDA, Sugarcane, Directorate of Agriculture, Chennai).
- The existing sowing tools for dryland have to be demonstrated intensively under farmers condition and refinement may be done if needed. Agronomist should also be involved in their processes (JDA, Tuticorin and Virudhunagar).
- TNAU should allot more resource towards dryland agriculture research through Govt. of Tamil Nadu. Basic information of Tamil Nadu Agriculture should be documented through survey, secondary data collection including information on indigenous technologies (JDA, Sugarcane, Directorate of Agriculture, Chennai).
- The indigenous farming system adopted by the farmers of Tuticorin district may be documented and used for further research under IFS (JDA, Tuticorin).
- Establishment of vetiver is the biggest problem especially in watershed areas (SE, Dept. of Agrl. Engineering, Coonoor and Erode).
- Sociological studies are needed to introduce dryland horticulture (JDA, Sugarcane, Directorate of Agriculture, Chennai).
- Low cost technologies have to be screened out from the technologies generated already (JDA, Sivagangai).
- TNAU should allot more resource towards Dryland Agriculture research (JDA, Sugarcane, Directorate of Agriculture, Chennai).
- For Dry lands, crops with hig' fertilizer use efficiency, moisture use efficiency should alone be recommended.

- Tamil Nadu Dryland Agriculture scenario should be documented including indigenous technologies to provide basic information for the introduction of location specific technologies (JDA, Sugarcane, Directorate of Agriculture, Chennai).
- Sociological studies are needed to introduce Dryland horticulture. Planning to be done by taking into considerations of suitable crops and availability of planting materials. Market promotion and post harvest technologies should be created for better adoption (JDA, Sugarcane, Directorate of Agriculture, Chennai).

Remarks of Scientists of TNAU

- Low cost technologies have to be screened out from the technology generated already from TNAU research stations in line with the work done in Maharashtra State (Director , CARDS).
- Investment in Tamil Nadu Dryland Agriculture through models considering the partial budgeting (Director, CARDS).
- All technologies should be promoted to farmers through farming system approach (Director of Extension Education).
- Transfer of technologies from research stations to farmers holding should be speeded up through holistic approach of massive scale demonstration in villages involving scientists and officials of Department of Agriculture through mission mode approach (Director of Extension Education).
- Introduction of crop insurance scheme in line with Gujarat State (Director, CARDS).
- Vetiver can be planted for soil and moisture conservation in Vertisols. This technology can be introduced in Alfisols, where bimodal rain exists (P & HD, Dept. of Agrl. Meteorology).
- Joint efforts of Agricultural Engineers and Agronomists needed in promoting mechanization in dryland because of acute labour problem. In addition, this introduction would reduce the cost involved in farm operations and this mechanization may be done with due participation of farmers and Government agencies. Contour bunding and compartmental bunding may be recommended for soil and moisture conservation (Professor of Farm Machinery).
- Dryland soils are low in organic matter and to sustain soil organic matter, available low cost material with in the farm may be recycled through IFS and composting (Director, SCMS).
- For technology transfer, the TANWA group, self help group and by conducting FLD involving Farmers Discussion Group may be effectively utilized (Director, SCMS).
- Separate Watershed Development Board may be established in Tamil Nadu for effective implementation of Dryland programmes (Director, CARDS and P & HD, Agrl. Meteorology).
- For effective intercultural operation in Dryland crops through mechanization, farmers should be

inculcated with the practice of row planting (Professor of Farm Machinery).

- Planning should be exercised to take the technology to the farmers, for which it is necessary to identify the centrs/crops/persons to conduct 100 hectares demonstrations (Director, SCMS).
- Agroforestry in Dryland should be included identifying constraints of the region concerned (Dean, Forestry)
- For carrying out compartmental bunding on large scale demonstration is to be advocated and necessary help may be integrated from Department of Agriculture and Department of Agrl. Engineering with due technical input from TNAU. The work may be carried out with funds from available schemes like NWDPRA, DPAP, DRDA, IWDP, IWSP etc.,
- Funds available in the ICAR schemes for Front Line Demonstration (FLD) and plan scheme for On-Farm Trials (OFT) may also be utilized for the demonstration (Professor of Agronomy).
- Mission mode approach may be followed with the identification of scientists (multi disciplinary) from Dryland research stations (Killikulam, Kovilpatti, Aruppukkottai, Ramanathapuram, Paiyur, Yethapur, Santhiyur and Coimbatore) and for technical input officials from Department of Agriculture and Agriculture Engineering for coordinating the work (Director of Extension Education).
- For this purpose, establishing Watershed Committee should be framed with the Department of Agriculture. Time frame may be fixed for the conduct of the demonstration.
- For maintaining soil fertility status in Dryland region, revival of the post of compost development officer is recommended. In this connection necessary help may be obtained from TANWA/NGO group wherever available (P & HD, Environmental Sciences).

Research needs of Dryland Agriculture

- Increasing moisture storage capacity with materials like polyhydroxyl.
- Medicinal plants may be tested in watershed.
- Developing a holistic model involving composted coir pith, seed hardening, biofertilizer and quality seeds.
- In respect of IFS, indigenous technology available in southern district may be evaluated against general model available with TNAU.
- Development of Decision Support System (DSS) including farming system approach.

INTEGRATED PACKAGES FOR THE MANAGEMENT AND CONTROL OF COCONUT ERIOPHYID MITE*

S.KANNAIYAN, SABITHA DURAISAMY, R.J.RABINDRA, G.RAMAKRISHNAN AND R.BASKARAN

Coconut is extensively grown in about 80 countries of the world with a total production of over 49 billion nuts. India ranks first in the world with 13 billion nuts per year and accounting for 24.5 per cent of the world production. The productivity of the crop is the highest in India with 7572 nuts/ha with an area of 1.90 million hectares. Among the coconut growing states, Tamil Nadu ranks second in area as well as production and productivity. It is grown in an area of 3.2 lakh hectares and the total production was 3716 million nuts with an average yield of 11620 nuts/ha during 1997-98. Several insect and non insect pests have been reported to affect the coconut palm. Recently outbreak of an eriophyid mite was noticed in severe form in different parts of Tamil Nadu. Although nine species of eriophyid mites have been reported to attack coconut leaves and nuts, Aceria [=Eriophyes] guerreronis (Keifer) (Eriophyidae:Acari) feeding on tender nuts has been found to cause heavy damage, resulting in loss of production of nuts.

Mite occurrence in Tamil Nadu

Stray occurrence of this mite was observed in Srivilliputhur in Tamil Nadu during 1984. This pest was considered to be a minor one till it was reported in a severe form from Kerala during February, 1998 and also from Pollachi and Udumalpet taluks of Coimbatore district in Tamil Nadu during August 1998 (Sathiamma *et al.*, 1998). Since then, this mite has been reported to cause damage in the districts of Dindigul, Erode, Vellore, Madurai, Theni, Thanjavur, Thiruvarur, Nagapattinam, Virudhunagar, Tirunelveli etc. The dry weather that prevailed in different districts was supposed to have favoured the multiplication of the pest during 1998, especially, in Pollachi and Udumalpet areas of Coimbatore district and in the districts of Erode and Dindigul. Since, February 1999, the incidence of the mite has been reported from other parts of the State also.

A cocosoid palm species, *Lytocaryum weddellianum* was recorded as an alternate host in Brazil/Mexico (Moore and Howard, 1996).

Mode of spreading of coconut mite

Spreading of mites mostly occurred through the wind. Spreading of this mite has also taken place through the mechanical transfer of the affected nuts from one place to another. Initially the mite occurrence was reported in coconut plantations in the Ernakulam district of Kerala. However, a recent survey revealed its occurrence not only in the adjoining districts *viz.*, Alleppey, Kottayam and Trichur but also spreading to other districts of Kerala and adjacent States *viz.*, Tamil Nadu, Karnataka and Andhra Pradesh. Mite occurrence was also observed recently in Andaman and Lakshadweep Islands. The occurrence of the coconut mite also noticed recently in Honkong, Malaysia, Philipphines, Singapore and Taiwan (Kannaiyan 2000 a). The dispersal of mite also occurs through insects, birds, lizards, squirrels and coconut husk during transportation.

Nature of damage

The mites infest and develop on the meristematic tissues of the growing nuts under the perianth by desapping the soft

tissues of the buttons. In the damaged buttons/nuts, initial symptoms will be exhibited in the form of triangular pale white or yellow patches close to each perianth. Different stages of mites live in the white, tender portion covered by the inner bracts of the perianth and suck the sap continuously. When the feeding activity is enhanced due to the increased population build up, it results in physical damage to the newly formed tissues which become necrotic. Intensive damage leads to the formation of brown coloured patches later on. In addition, as the nut grows in size, longitudinal fissures and splits occur on the outer surface of the husk. Occasionally, brownish gummy exudate is seen oozing out from the affected surface. Severe infestation results in poor growth, reduced size and copra content and malformed nuts with cracks and hardened husk.

Taxonomic identity of coconut eriophyid mite

A statewide survey was initiated with a view to augment the information's on the distribution, incidence, intensity of damage by the coconut mite and to collect the mite species from different regions of Tamil Nadu so as to confirm the identity of the mite. Survey conducted in Coimbatore and Erode districts revealed that mite species involved was *Aceria guerreronis* (Ramaraju, *et al.*, 2000). The survey work is being continued.

Biology

Mite, *Aceria [=Eriophyes] guerreronis* (Keifer) (Eriophyidae:Acari) are usually found under the bracts of fertilised female flowers and do not infest the unfertilized flowers. This mite is very minute in size measuring 200-250 micron in length and 36-52 micron in width with two pairs of legs. It is pale in colour with elongate body and worm like in appearance. The life cycle of this mite, which consists of egg, two larval instars and an adult stage, is completed in 10-12 days.

Yield loss

A survey undertaken recently by the ICAR team from Delhi in Tamil Nadu revealed that the infestation was severe (>40%) in Coimbatore, Erode, Thanjavur and Theni districts. It was medium (10-40%) in Madurai district and mild (0-10%) in Cuddalore and Pudukkottai and other districts. The estimated average loss of copra yield was found to be10-15% in Tamil Nadu as compared to 10 per cent in Benin, 16 per cent in Ivory coast, 30 per cent in Mexico and 11-28 per cent in St. Lucia (Moore and Howard, 1996).

Ecology

The mite population was found to be very high in 2 to 5 months old buttons. The population varied from 2 to 140 mites/4 sq.mm area along with large number of eggs in the infested nuts. The mites were found under the perianth about 42 days after opening of the inflorescence. Though the mites were found throughout the year, the maximum population was recorded during summer months. Fairly high mite populations were recorded even during the rainy months.

Studies on population dynamics

Studies conducted on population dynamics from September 1998 to November 1999 at Agricultural Research Station, Aliyarnagar revealed that the population of eriophyid mite was maximum during May (86/4 sq.mm) followed by April (73/4 mm^2) and March (70/4mm^2). The population was present even during rainy months (October – December'98). Two predatory mites *viz.*, *Amblyseius paspalivorus* and a tarsonemid were found inhabiting nuts underneath the perianth at low population (5 to 20/nut). The preliminary observations indicated that these predatory mites do not cause any appreciable reduction in the population of eriophyid mite. Another new field

experiment has been initiated from May 2000 at TNAU campus in 10 local tall coconut trees to study the population build up of eriophyid mite and its associated predatory mites, thrips and anthocorid bugs.

Sticky trap for monitoring mite population

More than 50 glass slides and 25 black card board strips and X-ray film strips smeared with vaseline/castor oil were placed at different levels (i.e. at crown level and above the crown level) to monitor the infestation of the mite. Results revealed that only 6 mites could be observed in the traps set at crown level.

Time of entry of mites in the bracts

Regular observations made during the course of study revealed that the mites were found between upper and lower tepals 42 days (6 weeks) after the opening of the inflorescence.

Mite migration activity

Studies on the pattern of mite migration over the nut was observed at four different time intervals *viz.*, 06.00,12.00,18.00 and 24.00 hrs. The observations indicated that maximum number of mites migrated at 6.00 a.m. in the morning.

Effect of eriophyid mite infestation on button shedding in coconut

The observations on button shedding in coconut palms infested by eriophyid mite and healthy palms showed only a very little difference in the level of shedding. The average number of buttons shed in mite infested palms was 39.69 as compared to 42.14 in uninfested palms. Among the dropped buttons from infested trees only 21.06 per cent of them were found to show mite damage and the remaining 78.94 per cent of the buttons were free from mite infestation.

Severity of mite damage in relation to the age of trees

Nuts in coconut trees of all ages are affected. In older trees, the mite incidence was higher. Trees of 15-20 years had 78-81% mite incidence (trees basis) and trees of 40 years had 96% mite damage.

Nut colour in relation to mite incidence

Nuts of all colours are infested by the mite. The nuts infestation varied from 89% in the Malaysian Yellow Dwarf to 100% in the Malaysian Orange Dwarf.

Varietal influence on button shedding /mite incidence

The data on button shedding in different varieties *viz.*, tall, dwarf and hybrids showed that it was lower in dwarf varieties (19.88%) as against 33.94% hybrids and 46.18% in tall varieties.

Screening of germplasms against eriophyid mite

The tender coconut cultivar kenthali recorded the lowest surface damage (20%) against other cultivars. Tiptur Tall is the highly susceptible variety which recorded the highest damage of 84 per cent followed St. Vincent, ECT and WCT (76%).

Effect of weather parameters on eriophyid mite

Initially farm surveys were carried out with 30 farmers selected in Negamum revenue village to collect first hand information on the coconut eriophyid mite. The survey revealed that flower formed during rainy season (NEM – North east monsoon season) escaped from the pest. Further it is also understood that infestation was very severe during the initial months of south west monsoon (SWM), that is June-July.

Based on this information, microclimate study was initiated in the selected coconut trees in the Coconut Nursery of TNAU from 20.01.2000.

Weekly observations were done. The study revealed that the relative humidity inside the crown was 3 to 6 percent higher than the ambient air relative humidity (open). Coconut leaf relative humidity and leaf temperature was in general more or less equal. It is observed that the leaf relative humidity was higher than leaf temperature whenever incidence free spathes were observed.

From the study made on weather and coconut button shedding, the results revealed that, high button shedding occurred during August – September and in November and mite would be one among the reasons for this shedding.

The optimum month for best spadix were September and October and it indirectly indicated that mite population would be lesser. If rains are received from January to April, coconut gave higher yield with mite free nuts.

Correlation was made between weather *parameters and mite incidence.*

- Maximum temperature has negative correlation with nuts affected during summer (March-May) and SWM season (June – September)
- Maximum temperature had positive correlation in NEM season (Oct. – Dec.)
- Relative humidity (RH-morning) had negative correlation with nuts affected in summer and positive correlation in SWM and NEM season.
- RH (evening) had negative correlation in summer and positive correlation in SWM and NEM seasons.
- Rainfall had negative correlation in summer and positive correlation in NEM season.

Evaluation of insecticides as spot application and root feeding

Four field experiments, two in the Agricultural Research Station, Aliyarnagar and two in farmers' holdings, one each at Avalur (Erode dt.) and Thathur (Coimbatore district) were conducted to evaluate the bioefficacy of certain insecticides/acaricides against the mite during October-December'98. In all the four field experiments, two round of spraying/root feeding were given and observations were made on the mite population of the nuts.

Among the treatments triazophos 5 ml/l, monocrotophos 1.5 ml/l. recorded and methyl demeton 4ml/l recorded 70.3, 57.98 and 72.5 per cent mortality (Mohanasundaram *et al.*, 1999 and Ramaraju *et al.*, 2000).

Screening of spot application of chemicals on bunches.

Six insecticides at higher *concentration (5ml/l)* were evaluated for their efficacy against coconut mite along with FORS and monocrotophos root feeding. Among the chemicals tested triazophos 40 EC, monocrotophos 36 SL and carbosulfan 25 EC at 5ml/l were found to be highly effective recording lesser mite population and higher undamaged buttons of 100, 100 and 73.61% respectively 4 months after the first spray.

Experiments conducted at CRS. Veppankulam revealed that spraying of either methyl demeton 4 ml/l or monocrotophos 1.5 ml/lit. at 10 days interval significantly reduced the percentage of nut damage to 25% compared to 53% in untreated control. Spraying of *triazophos 5 ml/l and* carbosulfan 2 ml/l significantly reduced the mite population by 70 and 68 per cent respectively on 30 days after two rounds of spraying at 45 days interval. The neem oil 2% + garlic extract 2% have effected 63 per cent population reduction. FORS 4% either alone or in combination with

Fusarium sp. significantly reduced the mite population by 51 and 55 per cent respectively 15 days after spraying. The spray treatments of chemicals are more effective than the root feeding treatments (Muthiah and Bhaskaran, 2000).

Evaluation of ecofriendly chemicals (botanicals and fors)

Two field experiments were coducted to evaluate the efficacy of Fish oil rosin soap (FORS) 4 per cent (40 g/l) and other neem based botanicals *viz.*, spot application of neem Azal T/S 1% 5 ml/l and neem oil 3% and NSKE 25% in 100 ml as root feeding along with chemical insecticides. Among the treatments carbosulfan 25 EC at 2 ml/l was found to be the most effective in reducing the mite population by 77.05%. Besides, FORS 4% and wettable sulphur 0.5% recorded 49.20 and 50.29% undamaged buttons.

Comparison of quality paramiaters in mite infested and uninfested coconut

The harvested nuts were categorised, based on the external damage symptoms produced by the mite, into four grades *viz.*, grade 0 (no damage), grade 1 (25% damage), grade 2 (26-50%) and grade 3 (>50% damage). The effect of mite on quality aspects *viz.*, reducing sugars, oil content and peroxidase were compared for infested and uninfested nuts. The amount of reducing sugar in coconut water was found to be more in healthy nuts (0 grade nuts). The same trend was noted in case of the sugar content in kernel. The per cent reduction in oil content in infested nuts compared to healthy ones did not show much variation. In grade 3 nuts, the per cent reduction in oil content over healthy was 5.81. Peroxidase value was found to be less in healthy nuts (2.0 meq peroxidase / kg sample) while in grade 3 nuts it was 5.0 meq peroxidase/kg sample. The increased peroxidase value indicated that the infested nuts may quickly prone to rancid. As the oil becomes rancid the amount of free fatty acid released from the oil increased which also acts as an indicator of rancidity.

The effect of organic manures on eriophyid mite

The mean damage grade index percentage was maximum (50%) in the chemical fertilizer (alone) treatment. The least damage (29%) was seen in the treatment of neem cake 2 kg+bone meal 0.5 kg+mill ash 4 kg (dosage per tree per year). The treatment chemical fertilizer + farm yard manure (50 kg per tree) showed a mite damage of 49%. The results indicated that application of organic manures reduce the mite damage to a certain extent.

Effect of chemical fertilizer on the eriophyid mite

Increased application of potassium @ 3.5 kg / palm recorded the least mite infestation.

Effect of cropping system on the eriophyid mite damage

The damage grade per cent was 76% in the monocrop of coconut. When a single intercrop (bhendi or sunnhemp) is raised along with coconut, the mite damage was slightly less (73%) and with banana (single) intercrop, the mite damage was 70%. When high density multiple intercrops are raised over a period of few years, the damage was 58% to 64% only (Muthiah and Bhaskaran, 2000).

Fungal pathogens

Eight (8) fungal pathogens, *viz.*, *Exophiala pisciphiala*, *Paecilomyces lilacinus*, *Verticillium chalmydosporium*, *V. suchalosporium*, *V. lecanni*, *viz.*, *Beauveria bassiana*, *Metarrhizium anisopliae*, *Catenaria* sp. were tested against the coconut mite, under in-vitro conditions. Among the pathogens tested, *Fusarium suchlosporium* reduced the mite

population by about 30 per cent. It was suggested to test the fungi at higher concentration to obtain higher mortality of the mites.

Efficacy of the formulation developed at *azolla* laboratory

Based on bioassay studies conducted earlier a formulation containing some plant extracts, plant based oil and fungal culture filtrate developed at *Azolla* laboratory was tested against eriophyid mite under field conditions. The TNAU biocide formulation was applied at 30 ml/tree by root feeding method. Results revealed that the mite population was significantly reduced (Kannaiyan *et al.*, 2000).

Two bacterial isolates and seven fungal isolates were obtained from the eriophyid mite affected tissues of coconut. The bacterial isolates were tentatively identified as *Serratia marcescens* and *Pseudomonas* sp. and the fungal isolates were identified as *Rhizopus* sp., *Fusarium* sp., *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus terreus*, *Trichoderma* sp. *Penicillium* sp. The cell free extracts of bacterial isolates and the culture filtrates of fungal isolates were tested for their efficacy against the eriophyid mite. The results of bioassay study revealed that the culture filtrate of *Fusarium* reduced the population of eriophyid mite (Kumar *et al.*, 2000).

Root feeding of nutrients and growth regulators for inducing resistance and rejuvenation of coconut palms infested by eriophyid mite

The nutrient analysis of leaf samples of infested palms, after root feeding of nutrient mixture combined with NAA (40 ppm) and salicylic acid (200 ppm), recorded higher K, P, Mg, Ca, Zn, Fe, Mn, Cu and B compared to untreated infested control. Higher mineral content definitely provides toughness to resist the attack by sucking pests. Particularly K content in leaf has increased from 1.04 to 1.69%. As K is an activator of numerous enzymes, its increase helps to enhance the metabolic processes, so as to reduce the infestation of mite incidence.

Further the physiological investigations of infested buttons recorded higher amounts of primary and secondary metabolites like total phenols (65 mg/g), ascorbic acid (207 mg/100g) and total carbohydrates (8.17 mg/g) in the above treatment, imparting resistance to sucking pests. Accumulation of polyphenols increases the activity of polyphenol oxidase (PPO) activity under boron deficient condition. Oxidation of phenolics by PPO leads to production of quinones. Quinones are more toxic than phenols, which leads to cell damage and cessation of growth. Quinones produced by PPO, polymerised to brown pigments leading to browning of tissues. Wax content, acting like a mechanical barrier, was also high in the treatment as compared to control. NAA prevents button shedding by correction of hormonal imbalance.

Physiological changes due to salicylic acid

Salicylic acid induces resistance to pest and diseases. Salicylic acid is known to improve the plant P uptake. It protects NRase activity and turn over of proteins. It enhances the growth and reproduction. Salicylic acid reduces IAA oxidase activity which promotes the auxin content and flower production. The spathe production is increased from 10 to 15/palm/year. The treatment combination of nutrient mixture with NAA and salicylic acid was observed to retain higher percentage of buttons (43%) than control (16.3%).

Residues of insecticides used for eriophyid mite management in coconut

Residues analysis in coconut water and kernel samples was carried out after root feeding coconut trees with monocrotophos, triazophos and carbosulfan at Aliyarnagar, Bhavanisagar

and Cheripalayam for the management of eriophyid mite and safe waiting period for harvest has been fixed. Based on the results it is suggested that a waiting period of 45 days can be fixed for safe harvesting of nuts after root feeding either monocrotophos 36 SL (15 ml/palm), triazophos 40 EC (20 ml/palm) or carbosulfan 25 EC (15 ml/palm).

Management of eriophyid mite through nutrients

The following nutrients are included along with the recommended fertilizer schedule

i. Muriate of potash	-	1.5 kg/tree/year
ii. Neem cake	-	5 kg/tree/year
iii. Borax	-	50 g
iv. Gypsum	-	1 kg
v. Magnesium sulphate	-	0.5 kg

The above fertilizers are recommended based on the concept of keeping coconut trees healthy to resist any pest and diseases. Since K and neem cake known for such resistance they are being recommended. The experiments conducted at CRS, Veppankulam revealed that higher dose of K and neem cake reduced the eriophyid mite incidence. Further Ca, Mg and B are also known to induce some amount of resistance to mite. The experiments are being conducted.

Spraying devices for spot application of pesticides on coconut bunches.

Two models of slip on type ring spraying devices are developed for easy clamping and fitting to the top of the tree trunk.

a. Model I

The unit consists of three parts *viz.,*

i. Clamp

ii. Circle ring

iii. Lance with nozzle and hoses

The clamp is mainly for fitting the circular ring at the top of the tree. It is adjustable to suit any size of the coconut trees. The circle ring is designed based on the average distance of the bunches from the tree. Four number of spray lances in the bending posture are fitted to this circular ring to cover all the bunches. The nozzles are fitted to the lance and position of the nozzles can be adjusted to suit the bunch position. Each nozzle is connected with plastic hose and the four hoses from the nozzles are connected with main delivery line which extends upto the bottom of the tree so that it can be attached with the commercially available rocker sprayer or portable engine operated sprayer for spraying the chemical. The portable engine operated sprayer consists of 3.1 hp petrol start kerosene run engine with 3600 rpm speed connected to ASPEE HSP-TS 18 spray pump (Horizontal Single Piston pump) with a suction capacity of 12 lit per hour. The maximum pressure developed by the pump is 400 psi. To cover more bunches the spray lances are hinged to the circular frame with springs so that they can be oscillated from the bottom. The cost of the unit is Rs. 750.

b. Model II

The model I is further simplified by eliminating the iron ring and lances with a flexible hose. Because of flexibility of the hose, the nozzle can be fixed directly on the top of bunch. Any number of flexible hoses with nozzle can be attached to the ring. The cost of the unit for covering six bunches works out to Rs.300.

MANAGEMENT OF THE ERIOPHYID MITE

New integrated package of practices evolved

The chemical control is the only method so far followed for managing the mite in coconut. However, it was felt that it may not be always safe to totally depend on chemicals and also the mite may

develop resistance to the chemicals. Continuous use of chemicals lead to the residue problems over a period of time. Therefore a decision was taken by the Vice-chancellor to develop an integrated package consisting of cultural practices, nutrient management methods, biological and chemical control to manage and control the eriophyid mite in coconut. Accordingly, a multidisciplinary Task Force was constituted to conduct experiments and to develop a package. A Steering Committee headed by the Vice-chancellor gave direction and constantly monitored the progress of different experiments. Thus, a new integrated package of practices has been evolved (Kannaiyan, 2000b).

SPECIFIC RECOMMENDATION

Package of recommendations for the management of the coconut eriophyid mite

1. Fertilization

- Apply : Fertiliser Urea 1.3 kg
  - Super Phosphate 2.0 kg
  - Muriate of Potash* 3.5 kg

* Increased quantity is recommended to increase the plant resistance to the mite

- Neem cake application @ 5 kg/tree/year and

  Organic manure (well rotten FYM) @ 50 kg/tree/year

- Micronutrients
  - Soil application
    - Borax 50g
    - Gypsum 1.0kg
    - Magnesium sulphate 0.5kg

2. Acaricides

Apply TNAU-Agro-Biocide 30 ml by Root feeding followed by Root feeding of carbosulfan 15 ml + 15 ml of water 45 days later. A third round of TNAU-Agrobiocide 30 ml root feeding can be given 45 days after root feeding of carbosulfan.

		Cost (Rs.)
1.	TNAU-Agro-Biocide 30ml / tree by root feeding 2 rounds @ Rs. 6.00 each	12.00
2.	Carbosulfan 25 EC 15ml + 15ml of water/tree by root feeding one round	9.20
	Total	21.20

Note : Nuts should be harvested before treating with Carbosulfan.

Next harvest should be done only 45 days later.

Conclusion

The eriophyid mite, *Aceria [=Eriophyes] guerreronis* (Keifer) (Eriophyidae:Acari) is a minute one in micron size which spreads fast in the air and infests the coconut plantations. The site of infestation is on the basal surface of the ovary. The mites colonise inside the perianth, start multiplying inside and suck the sap of the nuts. Since the mite is congregating on the specific location inside the perianth, the conditions prevailed might favour the reproductive process and quantitatively the numbers increase significantly upto 12 weeks and then decline gradually.

Since the target sight of the infestation is inside the perianth, the application of either bio-pesticides or chemical pesticides are not so effective because the mite is protected inside the perianth. However, systemic biocides or any other biological or chemical product are likely to reduce the population dynamics in nature. Also, the predatory mites which are reported in coconut gardens are not that effective against the serious eriophyid mite infestation.

It has also been reported in the literature that the *Hirsutella thompsonii*, a fungus which could reduce the population of the mite, since the fungus would

colonise in the perianth and reduce the population of the mites naturally.

Therefore, an attempt has been made to develop a package of IPM so as to intercept the bio-chemical changes in coconut as well as the biological effects directly on the mite itself, which would reduce the population as well as the infestation level. A fungus *Fusarium* sp. was isolated from the dead mite in *Azolla* Laboratory, TNAU could reduce the population dynamics of mite when inoculated. The package of recommendations would help in checking the menace of the coconut mite and also improve physiological condition of the plant for better nut formation.

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REFERENCES

Kannaiyan, S. 2000a. Natural occurrence of eriophyid mite in Asian countries. **Technical Visit Report**. Tamil Nadu Agricultural University, Coimbatore – 641 003.

Kannaiyan, S. 2000b. Integrated packages for the management of coconut eriophyid mite. **Lead Paper presented in Interactive Workshop on coconut eriophyid mite** held on 19.05.2000 at Tamil Nadu Agricultural University, Coimbatore – 641 003.

Kannaiyan, S., K. Kumar, G. Gopalaswamy, P. Yasotha and K. Ramaraju. 2000. Evaluation of a formulation based on plant products, biocides and agrochemicals for its efficacy against eriophyid mite in coconut. **Paper presented in Interactive Workshop on coconut eriophyid mite** held on 19.05.2000 at Tamil Nadu Agricultural University, Coimbatore – 641 003.

Kumar, K., G. Gopalaswamy, S. Sujatha Lilly, P.Yasotha and S. Kannaiyan. 2000. Selection of antagonistic microflora effective against coconut eriophyid mite. **Paper presented in Interactive Workshop on coconut eriophyid mite** held on 19.05.2000 at Tamil Nadu Agricultural University, Coimbatore – 641 003.

Mohanasundaram, M., S.Kalyanasundaram, O.V.R. Somasundaram and R.Mahendran. 1999. Management and control measures for the coconut eriophyid mite, *Aceria guerreronis Keifer* (Eriophyidae: Acari) in Tamil Nadu. **Indian cocon. J., 29(9)**: 8-10.

Moore, D and F.W. Howard. 1996. Coconuts. In: **Eriophyid mites– Their biology, natural enemies and control**. (Eds.) E.E.Lindquist, M.W.Sabellis and J.Bruin, Elsevier Science, Publ. Amsterdam, pp. 561-570.

Muthiah, C and R. Bhaskaran. 2000. Survey, bioecology and management of eriophyid mite on coconut. **Paper presented in Interactive Workshop on coconut eriophyid mite** held on 19.05.2000 at Tamil Nadu Agricultural University, Coimbatore – 641 003.

Ramaraju, K., K. Natarajan, P. C. Sundara Babu, S. Palanisamy and R.J.Rabindra 2000. Studies on coconut eriophyid mite, *Aceria guerreronis*. K. in Tamil Nadu, India. **Paper presented in the International Workshop on Coconut eriophyid mite**. January 6-8, 2000. Coconut Research Institute, Sri Lanka. pp. 7-8.

Sathiamma, B., C.P. Radhakrishnan Nair and P.K.Koshy. 1998. Outbreak of a nut infesting eriophyid mite *Eriophyes guerreronis* (K.) in coconut plantations in India. **Indian cocon. J., 29 (2)**: 1-3.

PROCEEDINGS OF THE GROUP MEETING ON THE MANAGEMENT AND CONTROL OF COCONUT ERIOPHYID MITE

A total of 50 scientists of Tamil Nadu Agricultural University and Extension Staff from Department of Agriculture attended the group discussion on Management of Coconut Eriophyid Mite.

The Vice-Chancellor in his introductory remarks pointed out that the outbreak of eriophyid mite in coconut was first observed in Pollachi and Udumalpet areas in October 1998. It is found not only in the mainland, but also in Andaman Islands. Besides, it was observed in other Asian countries like the Philippines, Malaysia, Singapore, Sri Lanka, Taiwan and Hongkong. In the initial stages of outbreak of eriophyid in coconut, monocrotophos root feeding was recommended which gave 70 per cent control. Continuous use of chemicals leads to the development of resistance, destruction of natural enemies, environmental pollution and residue problems in the produce. Hence, a steering committee and a multidisciplinary task force has been constituted under the chairmanship of Vice-Chancellor to conduct research and develop a package for the management of mite. Based on the multidisciplinary approach, a new integrated package of practices viz., application of FYM, neem cake, higher dose of K, micronutrients, TNAU – Agro Biocide in alternation with insecticide carbosulfun for the management of coconut eriophyid mite has been evolved.

The Director of Agriculture in his remarks mentioned that in the International conference on eriophyid mite held on 6th January, 2000 at Sri Lanka, it was presented that in Cuba, the people are living with the eriophyid mite, since the incidence is there for the past several years. *Hirsutella thompsonii* has been found to give upto 80 per cent control in Cuba, Mexico and other South Americal countries. The extent of spread and damage in Tamil Nadu, action taken by the Department of Agriculture and subsidy provided to the farmers by the government in tackling this problem were emphasised. In the national level meeting on biosafety conducted at Chennai on 15.7.2000, Dr.Razaak, Plant protection Advisor, Government of India suggested that the bioefficacy of TNAU Agrobiocide should be tested. It was also felt in the meeting that the residue studies should be taken up with regard to break down products of carbosulfan. He also pointed out that the suggestion given by Dr.S.Jayaraj, National Professor to explore the possibility of using predatory mites for the management of eriophyid mite may also be tried.

The Director of Agriculture suggested that the efficacy of TNAU-Agro Biocide should be demonstrated under field conditions in different districts by the Joint Directors of Agriculture in collaboration with the scientists of TNAU. The biosafety of carbosulfan i.e. persistence in copra and coconut water should be studied in detail.

The Vice-Chancellor gave detailed account on Integrated package for the management of coconut eriophyid mite. He highlighted the following points.

- First occurrence of mite in Tamil Nadu
- Distribution
- Severity of mite incidence in different districts of Tamil Nadu
- Spread in India and other Asian countries
- Biology of eriophyid mite
- Nature of damage and symptoms
- A detailed account of the taxonomy
- Population dynamics, natural enemies, mode of spread and alternate host
- Time of entry of mite into the bracts and indicated that maximum mites migrated during 6.00 a.m.
- Biochemical changes taking place in the infested nuts
- Influence of neem cake, micronutrients, higher dose of K and FYM application
- Effect of carbosulfan, Triazophos and Fish oil rosin soap
- Residue levels of carbosulfan and waiting period
- Effectiveness of the root feeding of TNAU-Agro Biocide against coconut mite
- Antagonistic microflora
- Possible interaction with *Botrydiplodia*
- Farmers awareness and adoption and the results of the integrated approach for the management of coconut mite. The package of practices / recommended by TNAU for the management of eriophyid mite of coconut was also explained.

The following are the important points discussed in the group meeting

The Director of Agriculture, Chennai suggested to gather more Information on Economic Thrshold level (ETL). Residue analysis on the perianth / meristematic tissues covered by the perianth, breakdown products of carbosulfan given through root feeding and possibility of large scale preparation of the micro nutrient mixture recommended by State Agriculture Department at Kudumiyanmalai.

➢ Thiru. Ramakrishnan, DD(Oil seeds) Erode, asked whether the *Fusarium* administrated through root is pathogenic
The details about TNAU – Agro Biocide were clarified by the Vice-Chancellor, it was pointed out that there is not residue problem with regard to Agrobiocide. Since we use only Fusarium culture filtrate, there is no ristk of introducing the fungus into the plant and it is easily absorbed and translocated.

➢ Additional Director or Agriculture Cheenai asked whether there is any reduction in the germination of seednut infested with eriophyid mite?
Dr.R.Bhaskaran, Prof. & Head, Veppankulam, explained that the germination of seed root is not affected when the mite infested seed root is used for raising the seedlings but the vigour of the seedling is affected.

➢ Th. Ramakrishnan, DD (Oil seed) , Erode wants to know about the recommendation of FORS?
Dr.R.J.Rabindra, Prof. & Head (Entomology) Informed that the trails are being progress with different formulations of FORS.

➢ Dr.Sabitha Doraiswamy, Director, CPPS informed that the evaluation of 'Biocatch' against coconut eriophyid mite supplied by M/s T.Stanes Co., Coimbatore, will be taken up by TNAU shortly.

- Dr.Srinivasan, Professor, Agricultural Economics presented the survey report of coconut eriophyid mite in Tamil Nadu

- Asst. Director of Agriculture, Solavandan informed that some farmers at Solavandan are practicing a novel method by soaking tender nuts in water and brushing the nut surface affected by the mite before selling. Is there any deterioration loss in the keeping quality or not due to this method?
  In reply, Vice-Chancellor informed that the keeping quality of affected tender nut soaked in water will be tested – (Action : Scientist, Food Science, HC&RI, Coimbatore)

- Director of Agriculture requested to take up further studies on predatory mites and identification of alternate chemicals to carbosulfan.
  Vice-Chancellor replied that studies will be continued to identify safer, effective alternate chemicals for carbosulfan against coconut mite (Action : Department of Entomology, Coimbatore ; CRS, Veppankulam and ARS, Aliyarnagar).
  Studies on predatory mites will also be continued. (Action : Department of Entomology, Coimbatore; CRS, Veppankulam and ARS, Aliyarnagar).

- Th.Venkatesan, JDA, Trichy raised the following points during the discussion whether we can encourage selling tender coconuts in the Ulavar Sandai, since they contain some mite population.
  Vice-Chancellor replied that already the mite has been found / reported from all places, hence there is no need to prevant such activities. Director of Agriculture also endorsed the view expressed by the Vice-Chancellor.

  Application of need cake reduced the infestation.
  Vice-Chancellor also agreed the view and informed that already it has been included in the packages.

  Is there any problem in the uptake of TNAU-agro biocide due to the presence of plant products with oil base.
  Since it contains solvent, all the components of TNAU-agro biocide are extracted into the solvent and there is no problem of absorption.

JDA, Trichy also informed the gathering that the mite affected palms produced more number of nuts with not much reduction in the copra weight and also the juice quality is good.

Recommendations

- The field demonstration of TNAU Agro Biocide will be conducted in the following locations. The Additional Director of Oil seeds will be the Nodal Officer and the Coordinating JDA's are identified.

Districts	Coordinating JDA
Trichy, Thanjavur, Nagai and Tiruvarur	Trichy
Coimbatore, Erode and Salem	Coimbatore
Vellore, Thiruvallore and Kancheepuram	Vellore
Madurai, Theni, Virudunagar and Dindigul	Dindigul

The TNAU scientists will associated in the demonstrations and facilitate.

PROCEEDINGS OF THE SCIENTIFIC WORKERS' CONFERENCE HELD DURING JULY, 19-20, 2000 IN THE TAMIL NADU AGRICULTURAL UNIVERSITY, COIMBATORE.

On 19th, July, 2000 by 9.00, the Scientific Workers' Conference (Agri), 2000 started with a briefing by the Vice-Chancellor to accommodate the shift in the inaugural programme to the afternoon session. The Director of Research readout the list of participants for the five theme areas viz., (i) rice production (ii) maize production (iii) pulses production (iv) Dryland Agriculture and (v) Eriophyid mite. Then each group was requested to deliberate on the concerned theme issues in different seminar halls chaired by a respective chairman from the University and respective co chairman from the Dept. of Agriculture.

In the afternoon, the inaugural function commenced with the welcome speech by the Director of Research. The Vice-Chancellor, TNAU, delivered the presidential address. While presenting the agricultural development scenario in the country, the role of Agricultural Scientists in improving agricultural productivity was highlighted. In crop improvement, the Tamil Nadu's performs in rice productivity as No.1 state was lauded by the Vice-Chancellor and he complimented the scientists and extension workers for the same. The success of evolving ADT43 and CO47 was commended by him. Low yield potentials and high variability were the problems highlighted and the need for reorientation of research in improving productivity of pulses was insisted. While pointing out the low yield levels of millets, the Vice-Chancellor was of the view to reorient our research programmes in millets to improve productivity atleast on par with other states in the country. While pointing out on the existing wide gap between the demand for and supply of maize, the Vice-Chancellor indicated the possibility of bridging this gap by exploiting the potentials of hybrid maize. In this regard, the Vice-Chancellor also indicated the need for developing new value – added products.

The Vice-Chancellor felt that though we are No.1 in the productivity of groundnut in the country, we have to go for developing diversified varieties with bold kernels for desert purposes, etc. While highlighting the importance of red rot disease, the Vice-Chancellor pointed out that in order to developing red-rot resistant sugarcane variety a scheme has been launched with the financial support of Rs.2.75 crores for a period of 10 years from the sugarcane cess fund and the same is in progress in Sugarcane Research Station, Cuddalore.. The high performing SVPR3 in rice fallows, was commended by the Vice-Chancellor and hinted on the potentials for bringing more area under cotton in rice fallows.

Tapping the potentials of rainfed agriculture through raising horticultural and forest tree crops was also indicated by the Vice-Chancellor in addition to reformulating the enterprises mixes to maximize farm profit to the dryland farmers.

Regarding crop production, the Vice-Chancellor, critically apprised the gathering on the menace of Eriophyid mite on coconut and the initiative taken by the TNAU in managing this pest under his leadership. He also indicated the launching a research project under NATP with a view to develop a capeteria of package of practices to counteract the pest, through multi-disciplinary mission-mode approach. The Vice-Chancellor

specifically pointed out the frontier areas of research in the field of agriculture sciences. He stressed particularly on developing rice hybrids, transgenic plants, INM practices etc.,

The Director of Research highlighted the various research activities of the University. The salient findings of research were presented and discussed. The development of ADT43, ADT44 and CO47 rice varieties and ADTRH1 and CORH2 rice hybrids, promising cultures in rice, gingelly, groundnut etc., throwing rice seedlings as a technique of planting, the paddy seed drum sowing equipment and evolving disease and pest resistance transgenic rice plants, high yielding vamban varieties etc were highlighted by the Director of Research. Finally, the multi-disciplinary research approach in tackling the menace of Eriophyid mite in coconut was also briefed by the Director of Research. Breeder seed production and distribution and source of the newly developed cultural practices were discussed.

The chief Engineers (Agrl.Engg) traced back the historical perspective of the developmental activities in Agrl. Engg in Tamil Nadu. The chief Engineers gave a holistic picture with reference to various soil and moisture conservation measures, implemented by the Department of Agrl. Engg. He also indicated as to how the mechanization in Agriculture has slowly crept in different stages in Tamil Nadu and commended the farmers in the maximum use of tractors, tillers, pumpsets and thrashers in the recent times. The Chief Enginner further indicated that the combined harvesters and heavy machineries like bulldozers are made available to farmers on reasonable hire basis. He has also outlined the activities of the Agrl. Engineering department in the wasteland and watershed development programmes like land shaping and levelling, contour bunding and construction of waste weirs, check dams, percolation ponds etc.,

The Director of Seed Certification described the major role played by the seed certification department in producing and assuring quality seeds to the farmers. He described the seed certification activity carried out by the department right farm planting till harvesting, etc., that assures quality and purity of seeds to the end users viz the farmers. The Director also pointed out the steps taken by seed certification department in enforcing quality control measures adopted at the seed retail points, for the availability of quality seeds to the farmers. The Director also pleaded technical support from the University in perfecting the 'modus operandi' for producing quality hybrid seeds and in testing some of the newly introduced improved crop variety seeds from other states into Tamil Nadu.

The Director of Agriculture in his special address indicated that Tamil Nadu Govt. has set a target to achieve 7 tonnes of paddy per ha by the end of 9th five year plan and hence requested required technologies and strategies suited to different regions viz., garden wet & dry land areas etc., In this context, he stressed the need for developing appropriate technologies. While emphasizing importance of developing rice hybrid, the Director of Agriculture expressed that a different strategy needs to be thought of for hybrid seed production.

The Director of Agriculture Commended the initiative taken by the Vice-Chancellor, TNAU in evolving package of practices in controlling the Eriophyid mite through multi-disciplinary

approach and the development of TNAU bio-cides. He also felt happy in the way in which the SWC has been organized this time. The Director of Agriculture while commending the better support that existed between the Department of Agriculture ad TNAU, he assured the same for ever. He also pleaded with the officers of the Department of Agriculture to have effective interactions with the University Scientists, particularly for the benefit of the farming community.

In the inaugural address the Secretary to Govt. Agri. Department Commended the excellent linkage existing between the Department of Agriculture and TNAU. While highlighting the high productivity levels realised in Tamil Nadu in major crops like Paddy and Sugarcane, he lauded the research activities and the initiatives taken by TNAU in tackling the current problems like eriophyid mite infestation, redrot in sugarcane, enhancing the productivity by DAP foliar spraying in pulses, developing rice hybrids, waste land development planning etc.,

Secretary also gave an overall view with reference to various agrl development activities in the State like *Ipomoea* eradiation, DAP foliar application in pulses, supply of *rhinocerous* trap, cultivation of cole vegetables in plains, supply of disc ploughs and tarpaulins at subsidized rates, creation of marketing complexes and cold storages and the construction of thrashing floors in the villages etc.,

The secretary also highlighted the steps taken by the Government of Tamil Nadu in containing the price fluctuations of coconut, cultivation of cashew in wastelands on long-lease basis by the cooperates, replacement of sorghum by maize, production of value added fruits and vegetable products etc., The need for increasing area under cotton in the state was also stressed by the Secretary to Government.

On the next day, 20.07.2000, the concerned Chairman of the five different theme areas presented the summary of the deliberations as detailed below :

Rice Production Technology

The Director of Research and the Chairman of this group presented the salient features of the deliberation held in the session. (Annexure I).

Popularisation of hybrid rice, standarisation of hybrid seed production and seedling throwing technique merited in the discussion.

JDAs of the concerned districts have out lined the problems confronted in rice cultivation and the scientists of TNAU in turn suggested solutions to most of the problems.

Following are the recommendations emanated from the discussion

1. ASD 19 has to be cultivated only during samba, Pishanam and Thaladi (Late sowing must be avoided).
2. ASD 20 is to be cultivated in Kar, Kuruvai and Sornavari only. (Late sowing must be avoided).
3. Cultivation of ASD 19 in Erode district during samba season has to be discouraged.
4. Promising rice hybrids have to be evolved. So as to make them acceptable by the farmers for increasing productivity and hence production.

Pulses Production Technology

The Director of Centre for Plant Breeding and Genetics who chaired this group presented the deliberations (Annexure II). The following were the recommendations.

1. Varieties recommended for popularisation

Redgram
APK1, CO 5, COPH 2 (Hybrid) and Vamban 2

Blackgram
Vamban 3, ADT 2, ADT 3, ADT 5

Greengram
CO 6, ADT 2 and ADT 3

Horsegram : Paiyur 2

Cowpea
CO 6, Vamban 1 (Grain), CO 2 and Vamban 2 (Vegetable)

Bengalgram : CO 4

Soybean : CO 2

2. Necessary modification in the groundnut seed drill may be provided to accommodate redgram seeds for sowing as an intercrop.

3. A redgram variety to accomplish single harvest may be evolved.

4. Necessary changes in the crop production manual to correct the seed rate for rice fallow pulses as 30 kg/ha instead of 20 kg/ha have to be made.

5. The technologies like application of rhizobium, phosphobacteria, *Trichoderma viridae* may be popularized.

6. Developing high yielding pulses varieties.

Maize Production Technologies

The Dean AC & RI, Madurai who chaired this group highlighted the important points deliberated in the session (Annexure III) Recommendations made :

1. To popularize COH 3, sufficients seeds may be produced and made available on large scale to the farmers.
2. As the demand for Popcorn & sweetcorn is increasing efforts may be made to supply the seed material.
3. The existing wide gap between supply and demand for maize may be bridged by encouraging large scale cultivation.
4. As the cultivation of maize is having its own (*renaissance*) in the recent years in Tamil Nadu a full fledged study on the problems and prospects may be taken up including the costs, returns and its profitability to the farmers.

Dry land Technologies

The deliberations on the Dry land Agri were summarized and presented by Director, SCMS (Annexure IV).

Regarding controversies on Eucalyptus as water exhaustive tree crop, a status paper was called for from the Dean Forest College, Mettupalayam.

There was a demand for quality varieties of better performing neem trees. In this regard, the tissue culture study was indicated.

The Simaruba oil tree may be popularized among dry land farmers. For which, a detailed analysis of the ingredients in the oil and its suitability for human consumption and other uses is needed.

Management of Eriophid Mite

The Vice-Chancellor , TNAU has chaired the session and presented the salient points (Annexure V).

Recommendations

The field demonstration of TNAU Agrobiocide will be conducted in the following locations. The Additional Director of Oil Seeds will be the Nodal Officer and the Coordinating JDA's are identified.

Districts	Coordinating JDA
Trichy, Thanjavur, Ngai and Tiruvarur	Trichy
Coimbatore, Erode and Salem	Coimbatore
Vellore, Thiruvallore and Kancheepuram	Vellore
Madurai, Theni, Virudunagar and Dindigul	Dindigul

- The TNAU scientists will associate in the conduct of demonstrations.

- The keeping quality of affected tender nuts soaked in water will be tested – (Action : Scientist, Food Science, HC&RI, Coimbatore)

- Studies will be continued to identify safer, effective alternate chemicals for carbosulfan against coconut mite. (Action : Department of Entomology, Coimbatore; CRS, Veppankulam and ARS, Aliyarnagar)

- Studies on predatory mites will be continued. (Action : Department of Entomology, Coimbatore; CRS, Veppankulam and ARS, Aliyarnagar).

Following are some of the problems and solutions discussed.

- The problems encountered in the production of hybrid rice seeds were discussed and the need for perfecting the technique was felt.
- The problem of blast attack on rice varieties like ASD19 and ASD20 in Kancheepuram and Cuddalore districts were discussed. Avoidance of late planting of ASD19 in Samba, would avert the blast incidence, was the consensus arrived at
- There was a recommendation to increase the seed rate of pulses in rice fallows to 15 to 20 kgs per hectare.
- Possibility of evolving ETL for Eriophyid mite in coconut was also discussed.
- Evolving a redgram variety that has the synchronized flowering character so as to lend itself for a single harvest.